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ROENTGEN KYMOGRAPHY IN CONSTRICTIVE PERICARDITIS*

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THE clinical syndrome sometimes called adhesive pericarditis, but best designated as constrictive or compressive pericarditis, has been clearly described and is now well understood by the majority of clinicians. In the classical case, the symptoms and signs are characteristic and the diagnosis may be attained with ease. Many cases, however, do not exhibit themselves in typical fashion, hence the condition is not infrequently overlooked. Such an occurrence is particularly unfortunate because constrictive pericarditis presents one of the few types of heart disease for which a specific and rapid curative procedure, pericardiectomy, is available.

Constrictive adhesive pericarditis represents the sequel to an acute inflammatory condition of the pericardium resulting in extensive cicatrization. It may be either tuberculous or non-tuberculous in origin. That the non-tuberculous cases are of rheumatic etiology is not yet generally accepted. The disease is often recognized in two forms. In the first, internal adhesions are present between various portions of the pericardium (concretio). In the second, adhesions develop between the adjacent structures and the pericardium (accretio). These forms rarely occur separately and in most cases varying combinations of the two are present. When symptoms due to cardiac compression occur it is the thickening of the pericardium rather than the external adhesions which interferes with heart action. The clinical findings reflect the failure of the heart to fill and contract properly; especially is the inflow to the heart restricted. The cardiac output and stroke volume are definitely decreased, the circulation time is prolonged and the venous pressure is markedly elevated. Essentially there is a marked inflow stasis due rather to inability of the ventricles to expand and fill than to constriction of the veins or auricles. After operation there is complete relief or definite amelioration of nearly all the symptoms and clinical findings.

The conception of pericardiectomy was first introduced by Delorme in 1898, but it remained for Rehn[14] to successfully remove portions of the pericardium in 4 cases (1920). Churchill[7] in 1929 was the first to perform the operation in the United States and a second successful pericardiectomy was reported by Beck and Griswold[1] in 1930. Since then numerous reports on peri-

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cardiectomy have appeared regularly in the literature.[2,6,7,15]

It should be emphasized that here we have one of the few cardiac lesions for which there is at hand a specific therapeutic procedure which, in many cases, without great risk, results in the transformation of a completely disabled individual into one who is, if not cured, at least competent to perform his daily tasks. In scarcely any phase of the brilliant accomplishments of thoracic surgery during the past decade are the results more dramatic or more gratifying.

With this development, the importance of establishing an early and accurate diagnosis of constrictive pericarditis has become much more pressing. In this respect, the roentgenologic findings are of paramount importance since they provide direct evidence of the cardiac impairment caused by pericardial scarring. Of the specific roentgenologic methods, roentgen kymography is probably of greatest merit since it deals directly with important changes in the physiology and dynamics of heart action. It is therefore admirably adapted to the study of cardiac impairment in constrictive pericarditis and it is possible that this roentgenologic procedure may become the most important single method in the diagnosis of this disease.

Of the strictly clinical uses for roentgen kymography, the information which it offers in constrictive pericarditis is the most valuable. It is helpful not only in diagnosis, but also in the study of the onset and progress of the disease, and in estimating the results of surgery.

The first description of the roentgenological diagnosis of pericardial scars and adhesions was made by Hofbauer and Holzknecht (1907). Since then there have been reports by Butler and Dana,[5] Zdansky,[17] Kornblum, Bellett and Ostrum,[13] and Freedman.[8,9] The roentgen kymographic changes in cardiac compression due to pericarditis have been studied by Stumpf,[16] Johnson,[11] Berner,[3] and others.

The roentgen findings were clearly stated by Freedman who reported 14 cases of compression caused by pericardiac scar in 1937[8] and 8 more cases in 1939.[9] In addition to impaired, reduced, or absent cardiac pulsation, the roentgen findings relate to:

(1) The size and shape of the cardiac silhouette. The heart is likely to be relatively small and to attain a triangular or pear shape; occasionally it is irregular (Fig. 1*a*).

(2) Changes in the configuration of the heart in the inspiratory and expiratory phase. These are markedly diminished or absent.

(3) Limitation of mediastinal excursions in recumbent positions (right and left). The shift of the mediastinum, normally occurring with such a change in position, disappears.

(4) Changes in relationship between the anterior border of the heart and sternum during respiration. A paradoxical retraction of the sternum during inspiration occurs.

(5) The appearance of the diaphragm in its relation to the heart shadow. It is likely to be irregular and to show retraction with cardiac pulsations.

(6) Evidence of calcification in the pericardium. This is present in about 25 per cent of the cases (Fig. 1, *a* and *b*).

The findings listed above have been detailed in previous papers so will not be elaborated here. While they are important to the diagnosis of constrictive pericarditis, the crucial observations are related to the diminution of cardiac pulsations. It is essential to note that the superiority of the roentgenoscopic examination to that of the ordinary roentgenographic studies is particularly emphasized. This is to be expected since the diagnostic features rest upon the demonstration of impaired cardiac excursion rather than morphologic changes. As a means of recording the diminished pulsations in constrictive pericarditis, however, kymography is probably unexcelled.

In a general way, the roentgen kymogram may be considered a permanent rec-

ord of that which may be observed on the fluoroscopic screen. The registration of the cardiac motion in this way permits a leisurely study of the impaired motion of the heart and an opportunity to observe details ordinarily not visible in the coarse image of the fluorescent screen. In constrictive pericarditis, the findings are best exhibited on the left side of the heart and consist of a striking reduction in the amplitude of the waves which represent cardiac pulsation (Figs. 2*a* and 3*a*). The size of these waves can be measured if desired and accurate comparisons made. It should be noted that the reduction in the amplitude of the kymographic waves of the left ventricle is due to the fixation of the mediastinum as well as to the diminution in cardiac pulsation. The normal aortic waves are also reduced in size—a consequence of the reduced stroke output. The auricular waves occasionally may be increased. This has been attributed to transmission of the ventricular waves through the atrioventricular septum during ventricular systole (Griswold[10]).

Not only will general intrapericardial adhesions be made apparent in this way, but localized areas of constriction, which are often difficult to observe roentgenoscopically, exhibit themselves readily (Fig. 4*a*). Occasionally when adhesions are limited to a portion of the heart the remainder of the heart which is free of constriction shows increased amplitude of pulsation. These increased pulsations represent, in all probability, a summation, in which the suppressed cardiac excursions at the involved site are added to the normal movement of the free borders of the heart. Furthermore, the demonstration of a normal amplitude of cardiac excursions may be helpful in ruling out this diagnosis when the clinical syndrome is simulated by another condition (Fig. 6, Case IV).

Not only is roentgen kymography of value in the diagnosis of constrictive, pericarditis, but it is also useful in demonstrating the effects of any therapeutic procedure. The first report demonstrating changes in cardiac excursion following pericardiectomy by means of roentgen kymography was made by Johnson.[11] A case of constrictive pericarditis was described in which roentgen kymograms before and after operation are included. The roentgen kymographic examination before operation shows almost complete absence of ventricular pulsation. After pericardiectomy, several roentgen kymograms show striking improvement in the amplitude of cardiac pulsation along the left heart border. The same case was reported again by Griswold.[10] By this means a graphic demonstration of the release of the ventricles afforded by decortication can be obtained (Figs. 2*b*, 3*b* and 4*c*).

In order to demonstrate the usefulness of roentgen kymography under various conditions we are reporting herein some illustrative cases.

CASE REPORTS

Case I. Mrs. E. J., aged forty-eight, was admitted to the University Hospital on August 20, 1938, complaining of weakness, dyspnea on exertion, orthopnea, and precordial distress. The symptoms had been present for two years and were becoming increasingly worse. Gradual swelling of the ankles and abdominal distention were also observed.

The past history revealed an attack of rheumatic fever fifteen years prior to admission. Cardiac involvement had apparently developed at that time. On roentgenoscopy one year after her recovery she was told that "pus was present about her heart."

In recent years a diagnosis of cirrhosis of the liver had been made because of recurring ascites. Finally, a calcifying, constrictive pericarditis was discovered and the patient referred for surgical therapy.

Physical examination revealed a poorly nourished, nervous, white female who appeared dyspneic and orthopneic. Marked venous distention of the superficial veins of the neck, edema of the ankles and distention of the abdomen with fluid were observed. The liver was palpable 3 cm. below the costal margin. The lungs were negative to auscultation and percussion. The heart appeared slightly enlarged, but no murmurs were noted. There was total ir-

regularity of the cardiac rate with a pulse deficit. Pitting edema of both ankles was demonstrated. Venous pressure determinations made at varying intervals ranged from 20 to 25 cm. H_2O. The blood pressure was 114/78.

Electrocardiographic study revealed low amplitude and auricular fibrillation.

Roentgen Examination. Marked diminution of pulsation involving the entire heart was present on roentgenoscopic examination. The normal response to inspiration and expiration was absent. A roentgenogram of the chest (Fig. 1*a*) revealed calcification of the pericardium with most of the calcium distributed over the left border of the heart. Marked calcification of the mediastinal nodes was also present. The cardiac silhouette was only slightly enlarged and showed the characteristic pear shape. A minimal pleural effusion on the right side was noted. In the lateral view the marked calcification of the pericardium anteriorly, inferiorly and posteriorly was observed (Fig. 1*b*). Roentgen kymographic study of the heart (Fig. 2*a*) revealed the pulsations to be practically absent over both borders of the heart in every frame. Fairly good pulsations, however, were present in the region of the large vessels.

On August 23, 1938, a partial pericardiectomy was performed. A densely adherent pericardium was present over the entire heart. The calcification was so marked that it required bone shears to remove a portion of the pericardium. Decortication was done over the left and right ventricles anteriorly and posteriorly, but could not be completed on the right side because of the precarious condition of the patient. Convalescence was uneventful and the patient was discharged in good condition.

On the last visit to the hospital March 3, 1940, considerable improvement in the symptoms had occurred. The patient had gained weight, her abdomen had receded and edema of the ankles occurred only occasionally. There was still some dyspnea on exertion and some elevation of venous pressure undoubtedly due to remaining adhesions about the greater vessels. Considering the nature and duration of the process, the clinical result is very satisfactory.

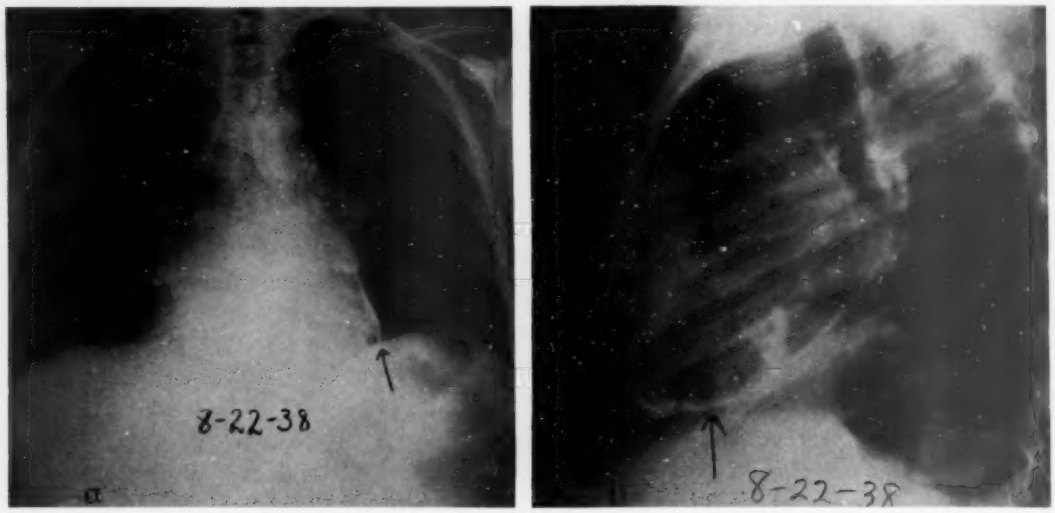

FIG. 1. Case 1.

a. Posteroanterior roentgenogram of the heart in a case of calcifying, constrictive pericarditis. The moderate enlargement in size and the irregular triangular shape are clearly demonstrated. Note the calcification along the left border (arrow).

b. Lateral view showing the classical appearance of calcification of the pericardium both anteriorly, inferiorly and posteriorly. There is also calcification of the mediastinal lymph nodes.

A number of roentgen kymograms of the heart have been made postoperatively (Fig. 2*b*). All demonstrate marked improvement in the cardiac pulsations over the left border. Shortly after operation the waves were of unusually great amplitude, but gradually decreased to a size approaching normal. A comparison between the pre- and postoperative roentgen kymograms (Fig. 2) reveals a striking difference in the character and amplitude of the

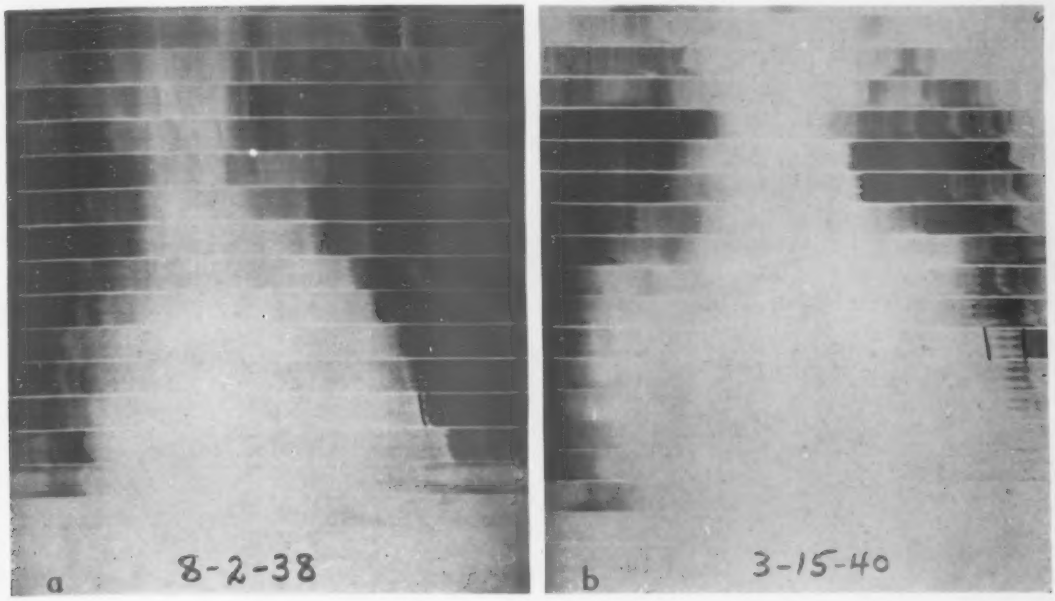

Fig. 2. Case 1.

a. Roentgen kymogram of the heart showing a markedly diminished pulsation throughout. The pulsations over the larger vessels are also diminished but are somewhat greater than those at the cardiac borders. Almost no pulsation on the right side can be made out. On the left the amplitude of pulsation is shown by the two lines drawn in the systolic and diastolic phases of the cardiac excursion. This is the typical roentgen kymographic appearance with a marked degree of constrictive pericarditis.

b. Roentgen kymogram made about seven months after operation showing the remarkable increase in the cardiac pulsations which are somewhat greater than normal at this time. The heart as a whole is increased greatly in size and the amplitude of pulsations on the left side are indicated by the two lines drawn in the systolic and diastolic phases. Comparison of *a* and *b* demonstrates graphically the change in cardiac function which has occurred.

cardiac pulsations. The heart increased markedly in size immediately after the operation, but has since become smaller. It is still much larger than on the original examination.

Comment. This case is recounted to show the characteristic findings in a typical case of calcifying, constrictive pericarditis. While the clinical diagnosis was perfectly obvious the roentgen kymographic studies have furnished valuable information as to the status of the cardiac excursion before and after the decortication. The success of the procedure is graphically demonstrated by this means. The increase in the size of the heart as well as in the amplitude of pulsations indicates the improved filling which became possible after the removal of the pericardium.

Case II. L. G., male, aged eight, was admitted to the University Hospital on February 28, 1938.

The patient was first seen at the Minneapolis General Hospital in 1934, with complaints of right-sided abdominal pain and low grade fever. Physical examination at that time revealed a progressively enlarging liver and spleen. The cervical nodes were also increased in size. Electrocardiographic tracing revealed some myocardial damage. On roentgen examination there was found a slight accumulation of fluid in the right pleural cavity and an abnormal configuration of the heart shadow suggesting mitral valvular disease.

The patient was re-admitted one year later with similar complaints and findings except that a considerable edema of the extremities and ascites had now intervened. The clinical diagnosis considered at this time was adhesive pericarditis.

In July, 1935, he was transferred to the Uni-

versity Hospital, where little change in the physical findings was noted. The total plasma proteins were unusually low, ranging from 3.36 to 5.0 per cent. Mobilization of proteins by every means failed. Because of this he was discharged in January, 1936, with a tentative diagnosis of idiopathic hypoproteinemia.

He was again seen in February, 1938, because of the marked increase of ascites and edema. Repeated paracenteses were done with removal of 4 to 6 liters of fluid every two weeks so that a total of 100,000 cc. of fluid was removed from the abdominal cavity. The total plasma proteins varied from 2.7 to 4.9 per cent. The circulation time was definitely prolonged and the venous pressure was 30 cm. of H_2O.

Roentgen examination of the chest revealed pleural effusion bilaterally. The cardiac silhouette did not appear particularly enlarged and the configuration was thought to be within normal limits. Roentgenoscopic examination again revealed a fairly normal cardiac silhouette but the pulsations were markedly diminished, and the normal response to respiratory changes was absent. Roentgen kymography (Fig. 3*a*) showed a marked diminution of pulsations throughout most of the heart shadow. In several of the frames, systolic contractions were completely absent. Pulsations of the aorta, although diminished in extent, were distinctly visible. With this information added to the clinical findings a diagnosis of constrictive pericarditis was made.

On November 25, 1938, pericardiectomy was performed, the left ventricle being decorticated first and subsequently the right so that the pericardium was removed from the entire surface of both ventricles. It measured up to 3 mm. in thickness, was densely adherent and showed no evidence of active inflammation.

The patient was given plasma to replace the lost protein. The circumference of the abdomen was promptly reduced in size, the urine output increased to a considerable degree. It was calculated that the patient spontaneously lost 3,300 cc. of fluid in a week's time.

Improvement was almost immediate. The plasma proteins returned to normal levels, an umbilical hernia which had been present disappeared. The patient now participates in sports and is not dyspneic. Within four months after the operation there was no edema, no dyspnea, and the patient was for the first time playing games.

The roentgen kymogram made on the last examination (Fig. 3*b*) is illustrated. After operation there was first a striking increase in the amplitude of the waves, the appearance suggesting increased pendulum motion. On the last examination there appeared to be a normal

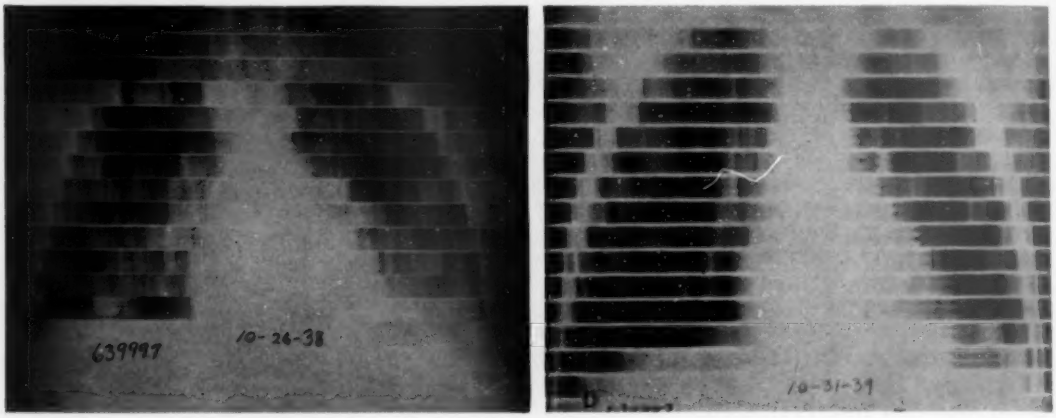

FIG. 3. Case II.

a. Roentgen kymogram in a case of constrictive pericarditis in a child. Note the rather small, triangular shaped heart, with little or no pulsation visible on either side. Diminution of pulsations is generalized and very marked.

b. Roentgen kymogram made about eleven months after pericardiectomy. The heart is increased somewhat in size and the amplitude of pulsation is practically normal throughout. This corresponds well with the remarkable change in the clinical picture, the child at this time having apparently normal cardiac function.

type of pulsation. The heart increased in size immediately after operation, but is now almost normal although larger than before the procedure.

Comment. The failure to make an early and accurate diagnosis of constrictive pericarditis even in a well-organized clinic with every facility at hand is here illustrated. Although in retrospect the diagnosis appears to have been obvious, the hypoproteinemia and extreme accumulations of peritoneal fluid confused the picture. Here the roentgen kymogram fortified the other evidences and added weight to the diagnosis. The brilliant results of surgery in such cases are well illustrated by the splendid result achieved for this child. Again the graphic demonstration of improved cardiac output is shown by the postoperative roentgen kymogram.

Case III. D. D., female, aged eleven, was admitted to the University Hospital on January 10, 1939, with a history of abdominal distention since infancy with gradual increase in size of the abdomen. The past history, aside from abdominal distention and fatigue, seemed unessential.

Physical examination revealed a poorly nourished, poorly developed girl with dilated superficial veins and a readily demonstrable ascites. There was a slight systolic murmur present with some reduplication of the second pulmonic sound. There was no pitting edema.

The venous pressure was found to range from 13.0 to 23.0 cm. of H_2O. The circulation time, arm to tongue, was eight seconds. Paracentesis of the abdomen yielded at various times some 4,000 cc. of fluid with a protein content of 30 gm. per liter.

Roentgen examination of the heart showed no enlargement of the cardiac silhouette. Roentgenoscopically, posterior displacement of the barium-filled esophagus was observed and corroborated by roentgenograms. There was a small area along the left heart border which showed markedly diminished pulsations. Except for this area of diminished pulsation, the findings were consistent with mitral stenosis.

Roentgen kymograms of the heart (Fig. 4*a*) revealed a consistent lack of pulsations in two

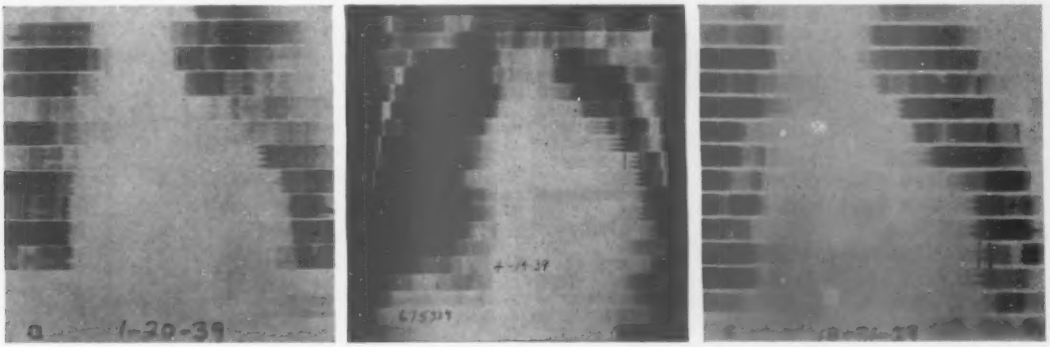

Fig. 4. Case III.

a. Roentgen kymogram in a case of localized constrictive pericarditis. Note the normal pulsations over the large vessels and fairly normal pulsations on the right side of the heart. There is some diminution of pulsation over the left side especially near the apex and in two frames (arrows) almost complete absence of pulsations can be clearly made out. This was a constant finding on repeated examinations and was observed roentgenoscopically as well. The localized character of the pericardial constriction was confirmed at operation and is well demonstrated in the roentgen kymogram.

b. Roentgen kymogram made one month after operation demonstrates the marked increase in the amplitude of pulsations which is well above normal. This is due in part to a greater swing of the heart. The increase in size of the heart is also clearly apparent. This type of change is commonly found shortly after pericardiectomy.

c. Roentgen kymogram made seven months after operation shows almost a normal situation. The heart is definitely smaller than it was immediately after operation, and the pulsations are practically normal as indicated by the lines drawn in the diastolic and systolic phases of the heart. Note the normal pulsations in the frames in which originally they were absent (arrows).

frames near the apex of the heart (arrow) in the same area where the diminution of pulsations was observed under the fluorescent screen. The pulsations, however, were not diminished over the upper left border of the heart. Over the remainder they were diminished, but not absent. After considerable study, a diagnosis of localized constrictive pericarditis was made.

On April 5, 1939, the thorax was opened with the purpose of exploring the pericardium. The heart appeared to pulsate normally with very little restraint of action except for an area near the apex. The pericardium was found to be laminated and markedly thickened with definite evidences of constriction but without mediastinal adhesions. Complete decortication of the heart was performed both anterior and posterior. Both atria as well as the vena cava were visualized.

The patient's convalescence was uneventful, and, on the last measurement of the venous pressure, it was 4.5 cm. of H_2O. The patient has fully recovered and has had no recurrence of ascites.

Roentgen kymographic examination was made shortly after operation (Fig. 4*b*) and showed an abnormally great amplitude of pulsations. The final examination was made on October 31, 1939 (Fig. 4*c*) and revealed an almost normal amplitude of all the cardiac pulsations with a particularly marked change in the area which previously showed no motion (arrows). The waves seem to be of about the same amplitude in all the frames at this time. The heart shadow is enlarged as compared with the preoperative examination.

Comment. The localized character of the constriction made it difficult to accept this diagnosis. Numerous suggestions were made to account for such a finding, but its constancy together with the presence of ascites, the absence of pulmonary congestion and the small size of the heart led to the correct diagnosis. This case illustrates the possibility that pericardial adhesions may diminish or abolish kymographic waves over a small area of the cardiac silhouette just as occurs in myocardial infarction. It may be noted that such suppressions of the waves have been observed in normal individuals but under such circumstances they are inconstant, varying from time to time. The repeated observation both roentgenoscopically and on the roentgen kymograms of a constant local area of absent pulsations was convincing evidence that the finding was of great clinical significance.

Relatively few cases of localized constrictive pericarditis have been reported, yet at certain stages of the disease such a finding should not be unusual. It is possible that the increasing use of roentgen kymography may lead to the earlier diagnosis of constrictive pericarditis, even when it is relatively localized.

CASE IV. Mrs. L. S., aged thirty-nine, was admitted on October 17, 1938 and died on November 28, 1938. The patient gave a history of progressive enlargement of the abdomen during the past four weeks. There was dependent edema for the past ten days. Pain in the left costovertebral angle was also present, apparently related to an injury received two years previously. The laboratory findings were negative except for the plasma protein which showed a total of 6.4, albumin 2.8, globulin 3.9. On examination the patient was obese, somewhat dyspneic, but without cyanosis or orthopnea. There was no visible distention of the veins of the neck, no enlargement of the heart on percussion or on roentgen examination. The blood pressure was 120/100. There was marked edema of the lower extremities up to the groin. The venous pressure was 22 cm. of blood and a paradoxical pulse was definitely noted. Seven liters of fluid containing 15 gm. per liter of protein had been removed from the abdomen by paracentesis. Electrocardiographic findings were almost normal.

Because of the increased venous pressure, the rapid accumulation of fluid and the paradoxical pulse, a diagnosis of constrictive pericarditis was considered. Dr. C. J. Watson suggested the diagnosis of Chiari's disease, that is hepatic vein thrombophlebitis with extension into the inferior vena cava.

Roentgenoscopic and roentgenographic examination of the heart gave the following findings. The heart was of transverse type, but this was believed to be due to the elevated diaphragms. There was no evidence of enlargement. On roentgenoscopic examination the heart pulsated normally. Roentgen kymograms (Fig. 6, L. S.) were made showing some diminution in the amplitude of pulsation, but this was only moderate and the appearance was not at

all suggestive of constrictive pericarditis. The absence of positive roentgen findings caused the abandonment of this diagnosis completely. The patient died suddenly on November 28, 1938.

At autopsy the heart appeared to be normal. The inferior vena cava was found to be completely occluded by a tumor mass measuring 5×10×5 cm. The mass ended at a point slightly below the entrance of the inferior vena cava into the right atrium and proved on microscopic examination to be a leiomyosarcoma. A thrombus was also present which filled most of the inferior vena cava and many of its branches.

Comment. This case is reported only to indicate the value of roentgen kymography in eliminating the possibility of constrictive pericarditis in a patient who presented some of the characteristic findings on clinical examination. The venous obstruction present was notable in that it appeared to involve only the veins connected with the inferior vena cava. In other respects also, especially the rapidity of onset, the clinical findings differed from those of typical constrictive pericarditis. Nevertheless the absence of roentgen kymographic evidences of reduced cardiac impulses was a helpful factor in the diagnostic considerations.

Case v. K. T., male, aged fifty-seven, came into the University of Minnesota Out-Patient Department complaining of nausea, some tendency toward vomiting and heart burn. The patient stated he had suffered from an abscess of the right lung three years previously, but there were no other significant facts in the past history. At the present time he has no complaints referable to the heart or lungs.

Roentgen examination of the gastrointestinal tract was done with a view to excluding a lesion of these organs. During the course of the routine roentgenoscopy of the chest, calcification of the pericardium was observed. Roentgenographic examination was also made demonstrating a considerable area of calcification along the left side of the heart and also along the inferior border, obviously within the pericardium. There were diaphragmatic adhesions and pleural thickening on the right side. On roentgenoscopic examination, however, the pulsations of the heart appeared entirely normal. Roentgen kymography was undertaken (Fig. 6, K. T.). The amplitude of pulsations was normal throughout the heart, even the areas of calcification showing a typical normal excursion. In view of the absence of any symptoms of constrictive pericarditis and the absence of roentgen signs of compression of the heart itself, no treatment of the pericarditis was considered. Roentgenographic examination revealed the heart to be within normal limits in size. There was a slight tendency toward a triangular shape and some evidence of external pericardial adhesions.

Comment. This case is cited to indicate the fact that calcification of the pericardium does not necessarily carry with it a complete fusion of the pericardium or even any extensive internal adhesions. We have observed 3 other such cases of calcification of the pericardium without any constriction. Roentgen kymography is of importance in such cases to demonstrate conclusively the non-compressive character of the lesion.

Case vi. A. J., male, aged twenty-eight, was first admitted to the University Hospital on August 13, 1939, suffering from congenital hemolytic jaundice. The symptoms and signs were typical so need not be described. The heart showed numerous murmurs. There was a history of rheumatism in childhood. Nevertheless, the cardiac signs were thought to be the result of the long standing anemia. A history of exertional dyspnea and palpitation was also explained in the same way.

Roentgen studies of the heart were made. It was found to be generally enlarged, but to a very moderate degree. The roentgen kymogram (Fig. 5*a*) exhibited rather pronounced waves particularly in the areas of the right ventricle with pulsations of moderate amplitude over the remaining portion of the heart.

The venous pressure was 7.5 cm. of H_2O. The vital capacity was 4,300 cc. The hemoglobin was 41 per cent and the red blood corpuscles numbered 3,200,000. Icterus index at this time was 146. The remaining laboratory findings were as might be expected.

On September 6, 1939, a 2,000 gram spleen, characteristic, in its gross and microscopic appearance, of congenital hemolytic jaundice was removed. The postoperative course was uneventful. The icterus index on September 11, 1939 was 10. The hemoglobin went up immedi-

ately to 78 to 88 per cent with a concomitant rise in the count of red blood corpuscles. The systolic murmurs heard over the heart disappeared and the patient left the hospital apparently well recovered.

In March, 1940, the patient had an attack of what was thought to be influenza following which he developed a persistent dry cough with only occasional sputum. On May 1 he noticed that his abdomen had become enlarged, and this enlargement proceeded rapidly for the next two weeks. He was admitted for the second time on May 23, 1940, at which time jugular vein pulsation was visible in the neck, there was marked dilatation of the veins over the abdomen and the abdomen was greatly distended. There were evidences of fluid in the peritoneal cavity. The heart appeared to be somewhat enlarged, but no murmurs could be elicited.

The venous pressure at this time was 22.5 cm. of H_2O and ranged as high as 31.5 cm. of H_2O during his stay in the hospital. Vital capacity had fallen to 2,600 cc. and later fell to 2,100 cc. The hemoglobin at this time was 94 per cent but later dropped to 72 per cent. There was dyspnea, but no orthopnea.

Re-examination with roentgenoscopy and roentgenograms revealed the heart shadow greatly enlarged as compared to the previous examinations nine months before. Furthermore, there was a distinct diminution in the extent of the pulsations throughout the heart. Roentgen kymography was done June 19 (Fig. 5*b*), at which time pulsations were shown to be almost absent throughout the entire heart. In view of the absence of pulmonary vessel enlargement, despite the increasing size of the heart, a diagnosis of probable constrictive pericarditis was made. The patient was studied for two months during which repeated venous pressures, repeated roentgen kymograms and roentgenoscopic examinations were made. Venous pressure continued high throughout and the roentgen kymographic studies consistently showed the very small degree of pulsation. On August 12 the heart had diminished somewhat in size over the admission size on May 23, but was still definitely larger than on the original study.

On August 13, 1940, pericardiectomy was attempted. This was extremely difficult in that the heart was completely fused to the pericar-

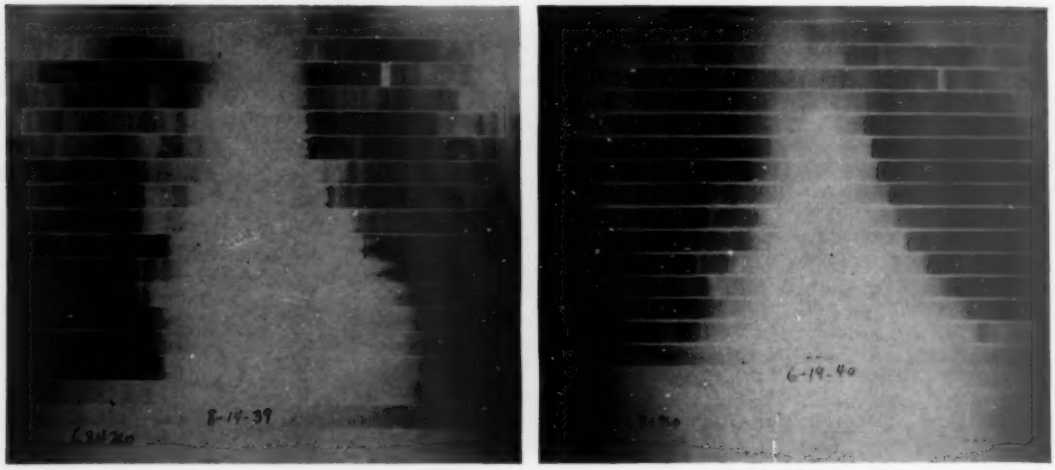

FIG. 5. Case VI.

a. Roentgen kymogram in a case of congenital hemolytic jaundice, showing a distinct increase in the amplitude of pulsations especially in the region of the right ventricle and over the larger vessels. There is some diminution of pulsations along the left border of the heart in the region of the left ventricle, but it is not of remarkable degree. The heart is slightly enlarged at this time, but is on the borderline of the normal.

b. Roentgen kymogram taken three months after the development of cardiac symptoms following an attack of influenza. The heart is increased remarkably in size as compared with the previous roentgenogram made nine months earlier. A marked diminution in pulsation is present throughout the heart on both sides, very little evidence of any expansion at all being made out. A comparison of *a* and *b* indicates the striking change which has occurred during the development of the constrictive pericarditis which, at operation, proved to be tuberculous.

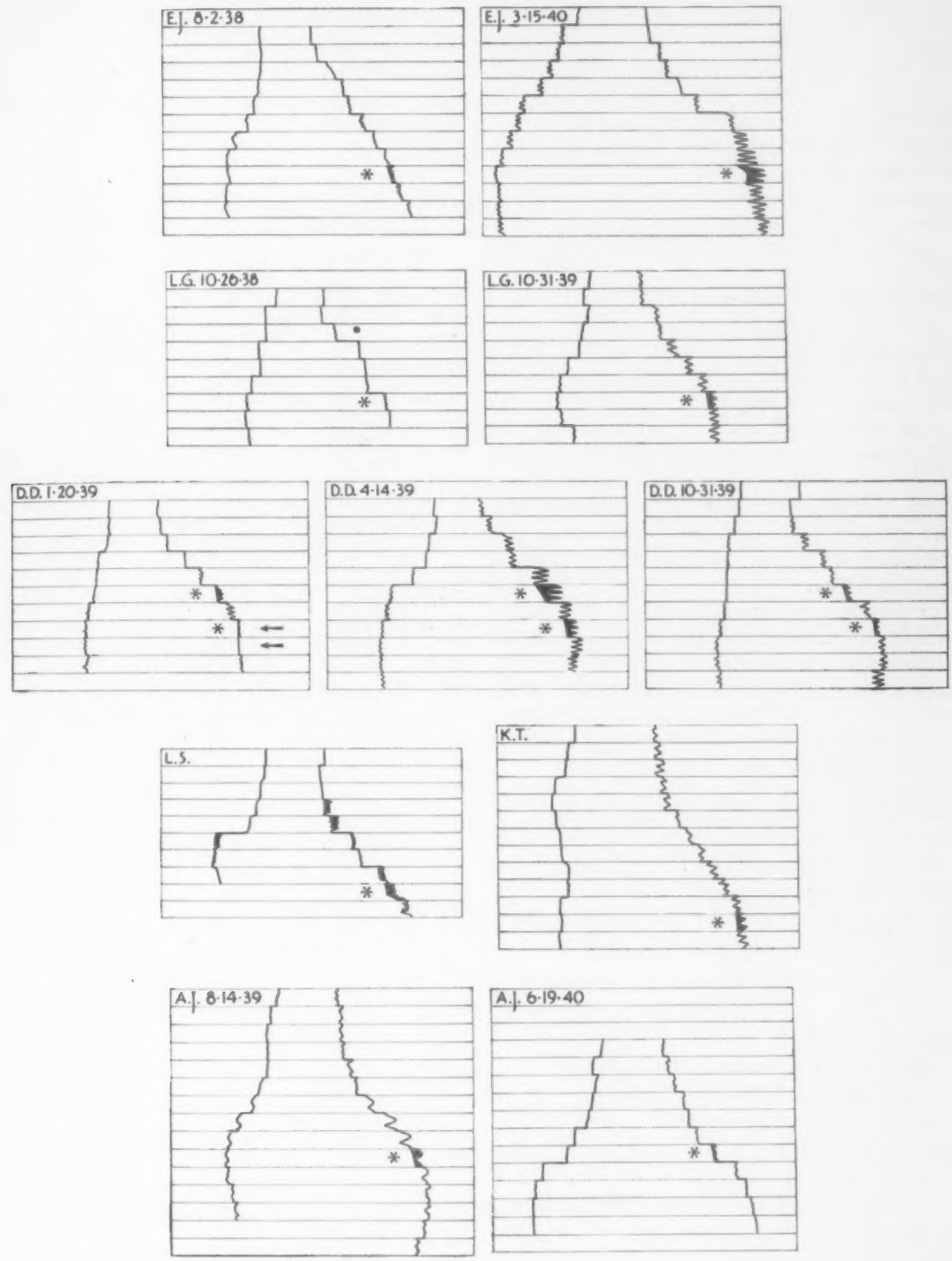

FIG. 6. Tracings of roentgenograms in the cases herein reported.

Case I—E. J. Case II—L. G. Case III—D. D.
Case IV—L. S. Case V—K. T. Case VI—A. J.

The amplitude of cardiac pulsation has been indicated by filling in between the diastolic and systolic phases of the cardiac cycle. The relatively normal roentgen kymograms shown in L. S. (Case IV) and K. T. (Case V) indicate the absence of roentgen kymographic changes in patients without constrictive pericarditis.

dium. Layer after layer of tissue had to be removed to get down to the myocardium. There were tremendous amounts of granulation tissue which cut with some difficulty and in its appearance and feel suggested a tuberculous process. Complete exposure of the ventricles was finally achieved. Numerous yellowish particles were found on the myocardium. No attempt to decorticate the atria was made.

Microscopic study showed a typical tuberculous pericarditis and tubercle bacilli were cultured from the pericardium.

Postoperative course was somewhat stormy with persistent accumulation of fluid in the left chest and around the pericardium. The patient bled rather freely during the course of the operation because of the enormous amount of granulation tissue and the tremendous number of vessels. The venous pressure dropped to 4.6 cm. of H_2O after the operation. Later it rose again to 19.5 and there was evidence in the roentgenogram of a reaccumulation of fluid about the heart.

A draining sinus from which tubercle bacilli could be obtained developed at the site of the pericardiectomy. Six months after the surgical procedure, his general condition was greatly improved. There was no further dyspnea, orthopnea nor edema. Aside from the draining sinus he appeared almost fully recovered.

Comment. This case is unique in that we were able to observe the actual development of a constrictive pericarditis by repeated roentgen examination and the roentgen kymograms, as illustrated, give a picture of the striking change which occurred in the pulsations of the heart. Although the first examination was made purely out of curiosity to determine what the roentgen kymogram would show in a case of marked anemia, it was of great value later for purposes of comparison. The confusing feature of this case was the enlargement of the heart which took place during the development of the process, just the contrary to what commonly occurs. This was no doubt due to the fact that some exudate had accumulated and the greatly thickened granulation tissue within the pericardium added to the size of the heart. It is probable that just before operation, the constriction was becoming greater and therefore the heart was beginning to diminish somewhat in size. The occurrence of a constrictive pericarditis as a result of tuberculous infection is not unusual and has been reported by others.[4]

DISCUSSION

The various cases detailed above illustrate abundantly the value of roentgen kymography as an accessory to other methods of examination in determining the diagnosis of constrictive pericarditis. This was especially important in Cases II, III and VI. Particular attention should be given to the localized nature of the constrictive process illustrated in Case III. When myocardial infarction is to be considered as a possibility, the differentiation from localized pericardial adhesions might be difficult. The utility of roentgen kymography in differentiating other types of venous obstruction which clinically simulate constrictive pericarditis is well shown in Case IV. Studies of the cardiac pulsations will be helpful in all cases of calcification of the pericardium to aid in determining whether or not surgery is indicated. This is well shown in Case V. The importance of repeated roentgen kymographic studies is abundantly illustrated in Case VI in which we were able to observe the actual development of the effects of internal pericardial adhesions. Likewise in Cases I, II and III, this method of examination gave valuable information as to the effects of pericardiectomy upon the motions and contractions of the heart. A graphic story of the change in cardiac function brought about by the operation is told by the roentgen kymograms made before and after the procedure. For further clarification, tracings of the roentgen kymograms of all the cases herein reported are shown in Figure 6.

SUMMARY AND CONCLUSIONS

The value of roentgen kymography as an aid in the diagnosis and study of cases of constrictive pericarditis is discussed. To

illustrate these points six cases are reported as follows:

1. Calcifying constrictive pericarditis showing the typical roentgen kymographic findings.

2. Constrictive pericarditis in a child presenting a difficult diagnostic problem the solution of which was aided by the kymographic study.

3. A case of constrictive pericarditis in which the roentgen kymogram revealed a localized area of absent pulsation near the apex of the heart.

4. Obstruction of the inferior vena cava by a tumor, simulating constrictive pericarditis, in which the normal roentgen kymogram assisted in the differentiation.

5. Calcification of the pericardium, with a normal roentgen kymogram indicating the absence of cardiac compression.

6. A case of tuberculous pericarditis, superimposed upon congenital hemolytic jaundice, in which a constrictive process occurred. The correct diagnosis was greatly facilitated by the roentgen kymograms and we were able to observe the development of the cardiac compression.

Three cases are included to demonstrate the value of the roentgen kymogram in recording the change in cardiac function which results from pericardiectomy.

Roentgen kymography permits registration of the cardiac excursions thus offering an opportunity for the study and review of the character of the heart motion. This method of examination offers an increased measure of accuracy and security in establishing a diagnosis of constrictive pericarditis. It also affords opportunity to observe graphically the effects of pericardiectomy, a surgical procedure of great value.*

REFERENCES

1. Beck, C. S., and Griswold, R. A. Pericardiectomy in treatment of Pick syndrome. *Arch. Surg.*, 1930, *21*, 1064–1113.
2. Beck, C. S. Acute and chronic compression of the heart. *Am. Heart J.*, 1937, *14*, 515–525.
3. Berner, F. Die Differentialdiagnose zwischen Accretio und Concretio pericordii circumscripta im Kymogramm. *Deutsches Arch. f. klin. Med.*, 1938, *182*, 88–100.
4. Blalock, A., and Levy, S. E. Tuberculous pericarditis. *J. Thoracic Surg.*, 1937, *7*, 132–152.
5. Butler, P. F., and Dana, H. W. Diaphragm excursions, normal and pathologic. *Am. J. M. Sc.*, 1928, *176*, 569–577.
6. Burwell, C. S., and Blalock, A. Chronic constrictive pericarditis: physiologic and pathologic considerations. *J. Am. M. Ass.*, 1938, *110*, 265–271.
7. Churchill, E. D. Decortication of the heart (Delorme) for adhesive pericarditis. *Arch. Surg.*, 1929, *19*, 1457–1469.

7a. Churchill, E. D. Pericardial resection in chronic constrictive pericarditis. *Ann. Surg.*, 1936, *104*, 516–529.

8. Freedman, Eugene. Roentgenological diagnosis of cardiac compression due to pericardial scar. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 739–752.
9. Freedman, Eugene. Inflammatory diseases of the pericardium. Am J. Roentgenol. & Rad. Therapy, 1939, *42*, 38–46.
10. Griswold, R. A. Chronic cardiac compression due to constricting pericarditis. *J. Am. M. Ass.*, 1936, *106*, 1054–1057.
11. Johnson, S. E. The roentgenkymograph as a new aid in the diagnosis of adhesive pericarditis. *Surg., Gynec. & Obst.*, 1935, *61*, 169–174.
12. Johnson, S. E. Roentgen kymography considered in relation to heart output, and a new heart index. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 167–174.
13. Kornblum, K., Bellett, S., and Ostrum, H. W. Tuberculous pericarditis. Am. J. Roentgenol. & Rad. Therapy, 1933, *29*, 203–213.
14. Rehn, L. Ueber pericardiale Verwachsungen. *Med. Klin.*, 1920, *16*, 999–1003.
15. Stewart, H. J., and Heuer, G. J. Measurement of the circulation in chronic constrictive pericarditis before and after resection of the pericardium. *New York State J. Med.*, 1939, *39*, 2183–2187.
16. Stumpf, P. Das röntgenographische Bewegungsbild und seine Anwendung (Flächenkymographie und Kymoscopie). (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Ergänzungsband 41.) Georg Thieme, Leipzig, 1931.
17. Zdansky, E. Zur Diagnose der Concretio und Accretio Cordis. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1931, *44*, 48–60.

* For discussion see page 790.

AN ATTEMPT AT THE CLINICAL EVALUATION OF ROENTGEN KYMOGRAPHY

A SHORT PERSPECTIVE BASED ON SIX YEARS' STUDY*

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THE multiple-slit method of cardiac roentgen kymography has been used in this country for six years, but only in the past three has it been utilized by a fair-sized group of roentgenologists. This six year period has given us some experience and a short perspective of the procedure. In order to crystallize these views, we have analyzed our work on kymography for the past year from July, 1939, to July, 1940, with regard to: (1) the frequency with which roentgen kymograms were ordered, (2) for what diagnostic purpose, and (3) if they contributed any information (Table I).

TABLE I

FREQUENCY, JULY, 1939–JULY, 1940

Total number of roentgen kymograms	212
Private patients	158
136	(films)

During that year, 212 cardiac roentgen kymograms were made. Of this total, 158 kymograms were made on 136 private patients. It is this group that we analyzed in the hope of estimating the value placed on kymography by the practicing physician. This is an important gain, as in the beginning it was necessary to beg for patients, and the films were necessarily made without charge.

In Table II we compared the frequency with which kymograms were ordered to the number of requests for other diagnostic measures. During this year 18,043 roentgenographic examinations were made, or 114 roentgenograms for every kymogram. About 10,500 patients were admitted to the hospital, and only 96 of these had kymograms, or about one for every 109 patients. The total number of electrocardiograms for the same year was 3,847. When compared with the total number of roentgen kymograms, there were 18 times as many electrocardiograms. If only the number of electrocardiograms made on hospital patients is used, the figure becomes one roentgen kymogram for every 25 electrocardiograms. It is apparent from these figures that roentgen kymography is not a routine procedure and is restricted to a selected group of cardiac patients.

To discuss the type of cardiac case in which kymography was of clinical value, we classified the 136 private patients into groups according to the final clinical diagnosis. The electrocardiographic and roentgen kymographic reports were compared, and they in turn with the clinical diagnosis. We also attempted to estimate if the kymographic examination had contributed any information or had been helpful in forming the final diagnosis. It is admitted that such an analysis is based on the elusive "personal equation," but no other method is available.

TABLE II

THE FREQUENCY WITH WHICH ROENTGEN KYMOGRAMS ARE MADE AS COMPARED TO OTHER DIAGNOSTIC PROCEDURES

Roentgen examinations 18,043	1 in 114 examinations (158)
Hospital admissions 10,500	1 in 109 patients (96)
Electrocardiograms 3,847	1 in 18 examinations (212)
Hospital electrocardiograms 2,411	1 in 25 examinations (96) hospital

* From the Edward Mallinckrodt Institute of Radiology, Washington University School of Medicine, St. Louis. Read at the Forty-first Annual Meeting, American Roentgen Ray Society, Boston, Mass., Oct. 1–4, 1940.

First, we shall consider those types of cases in which kymography has been used the least and lead to a discussion of those in which it has been used the most. In the first group (Table III) only one patient with aortic regurgitation was kymographed. This disease is easily recognized by any practitioner. It can be diagnosed from the kymogram, but there is no need for it.

One case of subacute bacterial endocarditis was kymographed. This disease does not give rise to characteristic kymographic waves and is unrecognized as such. The kymogram did, in this particular case, demonstrate the presence of a pulsus alternans which was not recorded by the electrocardiograph. Pulsus alternans is considered a bad prognostic sign and indicates extensive myocardial damage. The clinician was aware that this patient had serious heart disease and myocardial change, but the kymogram gave him a little extra information.

Only one patient with congenital heart disease had a kymogram. In this case we were fortunate enough to demonstrate increased pulsations of the pulmonary conus and arteries which helped in establishing the diagnosis of a patent ductus arteriosus.

Two cases of cor pulmonale were kymographed, and in one of them the kymographic report was in error. In the other the increased pulsation of the pulmonary arteries at the hilum, the so-called "hilum dance," and hypertrophy of the right ventricle were reported. This observation strengthened the diagnosis.

Table III

Cardiac Disorders*	No.	Roentgen Kymograms in Error	Roentgen Kymograms Contributing to Clinical Picture
Aortic regurgitation	1		
Subacute bacterial endocarditis	1		1 (demonstrated pulsus alternans)
Congenital heart disease	1		1 (patent ductus arteriosus)
Cor pulmonale	2	1	1

* In this table and in Tables IV to VI only the principal clinical diagnosis was used although related diagnoses were also listed. It was found necessary to do this as otherwise the tables would be involved and complex.

Before continuing, we want to emphasize a basic fact, that the kymographic examination is not a complete cardiac study in itself, but is only one of a group of diagnostic methods and tests that the clinician may use to study a cardiac case and to aid him in a better and more complete understanding of the disease process.

Table IV

Cardiac Disorders	No.	Roentgen Kymograms in Error	Roentgen Kymograms Contributing to Clinical Picture
Soldier's heart	3		3 (electrocardiograms normal)
Cardiac psychosis	3		2 (ruled out cardiac disease)
Check-up	15		?15
Functional arrhythmia	3		? 3

Heading Table IV is the so-called "soldier's heart," "nervous heart," or the heart in neurocirculatory asthenia. In all 3 cases the kymographic report was in agreement with the clinical diagnosis. These individuals are usually of the asthenic habitus and have a long and narrow heart. On the kymogram are seen sharp, needle-like points at the completion of ventricular diastole. This observation was reported early by Stumpf.[5] We have been favorably impressed by the kymographic findings and believe that it is worth further study with our present militarist outlook.

Three patients with a diagnosis of a cardiac psychosis were kymographed. In 2 of them the kymogram demonstrated a normal heart and in this way aided in establishing the clinical diagnosis. The third patient was elderly, and the kymogram showed evidence of myocardial damage

but not sufficient to explain the patient's symptoms.

Fifteen patients are listed as "check-ups." Under this heading are those patients who required a complete work-up and in whom it was necessary to rule out the presence of heart disease. In each of these the kymogram was reported as normal. Normal reports are of significance, particularly if the patient is a worried and anxious high-powered executive with suspicious signs of coronary artery disease.

Table V

Cardiac Disorders	No.	Roentgen Kymograms in Error	Roentgen Kymograms Contributing to Clinical Picture
Aneurysm	7		3
Non-pulsating mediastinal tumor	7	1 (reported as aneurysm)	3

In this same category belong the 3 cases of functional arrhythmia. The kymograms were taken primarily to rule out any underlying cardiac disease.

The next group in Table v brings up the old problem of deciding whether a mediastinal mass is an aneurysm or a tumor. Seven patients were reported from the kymograms as having aneurysms and were subsequently diagnosed as such. All 7 of the non-pulsating masses were reported as tumors, but, as can be seen, one of them turned out to be an aneurysm. We have previously published our views on the kymographic diagnosis of these two lesions.[4] The conclusion, then as now, is that the kymogram is helpful in the differential diagnosis, but it is by no means infallible, as there are tumors that will show pulsation, and there are aneurysms that will not show pulsation.

The diseases listed in Table VI also offer problems in differential diagnosis. Only one case of adhesive pericarditis was examined kymographically and reported as such and later confirmed by autopsy. While adhesive pericarditis was diagnosed only once, the possibility of this disease had to be ruled out in many of the patients listed in other groups. On the kymogram the heart is enlarged, and the cardiac and aortic movements are diminished, the amount depending on the degree of constriction. Kymography has been of value to us in making this diagnosis and also in providing a better idea as to the degree of constriction present. Since only those cases of pericarditis with definite restriction of movement and/or signs of a cardiac tamponade will benefit from surgery, the detection of diminished movement becomes very important. Restricted movement can usually be recognized under the roentgenoscope, but the kymogram provides a graphic, detailed, and permanent record of these movements. Kymography has proved valuable in the diagnosis of constrictive pericarditis and occasionally in a localized pericarditis with adhesions binding the heart to the chest wall or in a mediastinopericarditis.

Two cases of pericardial effusion were examined and reported as such. The differential diagnosis between pericardial effusion and adhesive pericarditis is difficult, and the kymograms alone will not always differentiate between the two. Usually in pericardial effusion very small movements per-

Table VI

Cardiac Disorders	No.	Roentgen Kymograms in Error	Roentgen Kymograms Contributing to Clinical Picture
Pericarditis, adhesive, tuberculous	1		1 (postmortem)
Pericardial effusion	2		2
Toxic myocarditis	1		1 (eliminated diagnosis of pericarditis)
Rheumatic heart disease	13	3 (early)	3 (eliminated diagnosis of pericardial effusion)

sist over the border of the heart. They are smallest in the dependent portion of the pericardium and largest over the superior portion of the pericardium. If the effusion is sufficient to produce a cardiac tamponade, the movements of the aorta become small, and the picture is similar to that in adhesive pericarditis.

Severe myocarditis is also difficult to distinguish from adhesive pericarditis. In toxic myocarditis the cardiac movements are shallow with superimposed serrations, and they are usually seen over the entire heart. This particular patient presented the clinical picture of an infectious, adhesive pericarditis. The cardiologists deferred an exploratory operation on the pericardium because definite motion over the whole heart was recorded on the kymogram. There was a certain satisfaction in having this diagnosis confirmed at autopsy and hearing the pericardium pronounced normal.

Of the 13 cases of rheumatic heart disease there were 3 which were not reported as such from the kymogram. The 3 failures were in patients who were in the early stages of the disease. The kymogram does not become characteristic of mitral stenosis or mitral insufficiency until the valves are sufficiently damaged to alter the way in which the heart fills and empties. In rheumatic heart disease the kymogram is useful in confirming the clinical diagnosis, in ruling out an associated pericardial effusion, and in providing a gross estimate of the condition of the myocardium. Keys, *et al.*[1,2] have devised a method for obtaining a mathematical figure of the efficiency of the cardiac output. The method seems promising but should be confirmed by other workers.

The largest number of kymograms was made on patients with the diagnoses listed in Table VII. It is obvious that in the 22 cases of arteriosclerotic heart disease, the kymograms were not made to establish this relatively easy diagnosis. The same is true of the 21 patients with hypertensive heart disease. For the most part, the clinician was hoping to rule out other complications and also to gain information concerning the degree of myocardial damage or impairment. The cardiologist obtains a good idea of the condition of the cardiac muscle from the history and general appearance of the patient, from the blood pressure and the electrocardiographic readings, from the physical examination of the heart and exercise tolerance tests, and from the roentgenoscopic appearance of the heart. In most instances these sources of information are adequate, but in others the clinician is not completely satisfied. In these cases we have attempted to make a gross estimate of the degree of myocardial damage from the kymograms on the basis of diminished and irregular cardiac movements. If such reports can be developed and proved to be sound, the information will give a more complete picture of the cardiac status and will aid in forming a more accurate prognosis. We feel that such an estimate of myocardial damage is worth continued effort. The same estimate applies to patients with hypertensive heart

Table VII

Cardiac Disorders	No.	Roentgen Kymogram at Variance with Electrocardiogram	Roentgen Kymograms in Error	Roentgen Kymograms Contributing to Clinical Picture
Arteriosclerotic heart disease	22	3 (electrocardiogram reported normal)		8
Hypertensive heart disease	21	2 (electrocardiogram reported normal)	1	6
Coronary artery disease	17			8
Coronary artery thrombosis	15	3	2	7

disease, and, to a less extent, to those with coronary artery disease, angina, or even those with cardiac infarction. To avoid misunderstandings I want to emphasize (1) that 43 cases of arteriosclerotic heart disease and hypertension represent but a small number of the total cardiac patients with these diagnoses, (2) that in only about one-third of them did kymography contribute to a clearer picture of the cardiac status, and (3) that the kymographic estimate of myocardial damage is in the experimental stage and is dependent on personal experience.

The diagnosis of true angina pectoris and/or coronary artery disease is usually made by ruling out any other disease process which might account for the substernal pain with or without radiation down the left arm. The careful clinician hesitates to make this diagnosis because of the ominous prognosis and financial readjustments that may arise. Therefore, any diagnostic procedure that will increase the accuracy of this diagnosis ever so little should be worth while. Ten patients with this disorder were kymographed. In 5 of them the report was at least confirmatory. Three criteria were used in making the kymographic report of coronary artery disease; first, a limitation of movement of the left ventricle as compared to the right heart border; second, the presence of small serrations superimposed on the movement waves, and third, a straight or concave line to the border of the left ventricle. The first and last observations were made by Levene, Wheatley and Matthews.[3] In our studies we have never seen a patient with definite coronary artery disease or angina who had large, forceful, clear-cut movements of the left border of the heart.

The signs of cardiac infarction or coronary thrombosis on the kymogram are varied. The first and best known is the small area on the border of the left ventricle that is devoid of motion, or greatly diminished movement with adequate movement on each side. The second sign is a marked diminution in the movement of the entire left ventricle. The third sign is paradoxical movement of the left border of the heart. In this group of patients the kymogram failed to show evidence of cardiac infarction in one case. From previous experience we know that every infarct cannot be detected by kymographic study. On the other hand, 2 patients were diagnosed as having cardiac infarcts by the clinical findings and kymograms although electrocardiographic diagnosis was hardly suspicious. Last year we had the surprise of an autopsy confirmation of a kymographic report of infarct in a case in which the electrocardiographic findings were lacking. The impression should not be gained that this is the rule, for the superior value of the electrocardiograph is unquestioned. However, the electrocardiogram is not without failures.

Our review considers that in about half of the cases with coronary occlusion kymography has been of some value. We believe that it is of help in four ways: (1) in usually confirming the diagnosis and rarely in establishing the diagnosis; (2) in frequently localizing the site and extent of the infarct; (3) in providing a gross estimate of the degree of myocardial damage, and (4) in providing a means of following the process of healing.

CONCLUSIONS

This review may be briefly summarized in the following conclusions:

1. Roentgen kymography is not a routine procedure for the examination of all patients with heart disease. It should be restricted to a selected group of cardiac patients.

2. The interpretation of kymograms requires careful analysis and reasoning to avoid mistakes. Training, experience and a knowledge of heart disease are essential, just as a knowledge of pulmonary diseases is essential to the proper interpretation of roentgenograms of the chest.

3. The kymographic report is in no sense a complete study of the heart. Kymography is but one of many diagnostic methods that may be selected by the clinician to aid

him in a more thorough understanding of a particular problem.

4. In general, kymography is of little value in the cardiac cases in which the diagnosis is readily established and thoroughly understood. Kymography is of most use when the differential diagnosis is complex and the clinical picture obscure.

5. The kymogram affords another method of ruling out the presence of organic heart disease by the picturing of hearts of normal size and movement.

6. The use of kymography to provide a gross estimate of the degree of myocardial impairment is worth continued effort and development.

7. Kymography is recognized as being particularly helpful in establishing the diagnosis of pericarditis (adhesive, constrictive, and rarely, mediastinopericarditis), pericardial effusion, and, to a lesser degree, in substantiating the diagnosis of coronary artery disease and cardiac infarction.

8. We believe kymography is of value when used with discretion and with an understanding of its limitations as well as its possibilities.

9. Finally, the kymographic report is similar to all other laboratory reports in that it must fit the clinical picture as a glove does a hand. If not, one of the two is in error and the discrepancy must be corrected.*

REFERENCES

1. Keys, A., and Friedell, H. L. Quantitative measurement of the valvular efficiency of the heart. *Proc. Soc. Exper. Biol. & Med.*, 1939, *40*, 556–559.

2. Keys, A., Friedell, H. L., Garland, L. H., Madrazo, M. F., and Rigler, L. G. Roentgen kymographic evaluation of the size and function of the heart. Am. J. Roentgenol. & Rad. Therapy, 1940, *44*, 805–833.

3. Levene, G., Wheatley, F. E., and Matthews, H. Roentgen diagnosis of coronary disease. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 588–592.

4. Scott, W. G., and Moore, S. Roentgen kymographic studies of aneurysms and mediastinal tumors. Am. J. Roentgenol. & Rad. Therapy, 1938, *40*, 165–172.

5. Stumpf, P. Das röntgenographische Bewegungsbild und seine Anwendung. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Ergänzungsband 41.) Georg Thieme, 1931, pp. 1–78.

* For discussion see page 790.

AN EVALUATION OF THE ROENTGEN KYMOGRAM IN THE STUDY OF DISEASES OF THE HEART AND GREAT VESSELS*

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INTRODUCTION

THE modern method of graphically recording the movements of an organ on a single roentgenogram by projecting roentgen rays through multiple slits in a sheet of lead was developed from an idea introduced by Sabat[18] in 1911. He utilized a single slit and made relatively long records on a roentgen plate. Gött and Rosenthal[6] independently presented a similar idea in 1912. Subsequently Crane[4] (1916), Hitzenberger and Reich[10] (1923), and Knox[13] (1922) made improvements in the technique. To Stumpf[21] (1931) is credited the introduction of the multiple slit grid which is the basis of the kymograph now generally used. This apparatus has been described by detail by Hirsch.[8] The literature now contains a number of contributions on the subject of kymography and its application to the diagnosis of heart disease.[8,17,19,22,23] Just how much this method adds to the diagnosis and management of abnormalities of the heart and great vessels is still under discussion.

It is the purpose of this paper to present the results of a study of 179 unselected cases in which kymograms were made with an attempt to evaluate this procedure as a diagnostic method.

PHYSIOLOGIC MECHANICS OF KYMOGRAPHY

Of fundamental importance in the interpretation of the kymogram is the fact that only those movements will be accurately recorded which are in a direction both perpendicular to the heart border and parallel to the slits. The normal heart beat is composed of a number of distinct movements, the most important of which is the shortening of the papillary muscles in a direction parallel to the long axis of the heart and approximately perpendicular to the usual direction of the slits in the kymograph (Boehm[3]). Narrowing of the heart with systole takes place transversely and anteroposteriorly. Rotary movements of the heart have also been described.[21] Only the horizontal component of a complex cardiac movement will be recorded on the kymogram when the slit is horizontal.[14,22]

Ludwig[14] has demonstrated some of these movements diagrammatically. Figure 1*A* represents a sphere which has contracted uniformly in all directions. The distance of the contraction can be measured by a line drawn perpendicularly from the circumference of the smaller circle to the outer (AA′, BB′, CC′). However, if viewed in a kymogram only the line BB′ will represent the true lateral movement of the heart border. In Figure 1*B* a downward movement of the sphere has taken place in addition to the contraction. The broken lines represent the actual movement of the borders of the sphere. The solid lines represent the amplitude of the movement as would be seen in the kymogram. A similar situation is illustrated in Figure 1*C*, but the movement of the sphere is in an upward direction. In Figure 1*D* still another movement is introduced, namely, a shift laterally as well as upwards. At the point of intersection of the circumferences of the circles the inward movement caused by the contraction would be cancelled by the outward movement of the entire sphere. Consequently no movement would be recorded in the kymogram at this point. The problem of evaluating the amplitude of the pulsations becomes even more complex when the cardiac contour is

* From the Departments of Radiology of the Presbyterian Hospital and of the College of Physicians and Surgeons, Columbia University, New York. Read at the Forty-first Annual Meeting, American Roentgen Ray Society, Boston, Mass., Oct. 1–4, 1940.

substituted and other factors such as anteroposterior movements and transmitted pulsations are to be considered. From the foregoing, satisfactory measurement of the size of the heart by means of the kymogram, as suggested by Keys and Friedell,[12] or the application of a roentgen kymographic index as a measure of heart function, as suggested by Johnson[11] seems impractical.

An example of the effect of the movement of the aorta upon the wave tracing is shown in Figures 2*A* and 2*B*. At autopsy, shortly after the kymogram was made, the aortic arch was found to be markedly sclerotic and rigid. Nevertheless, because of the lateral movements of the arch, wave tracings simulating those produced by pulsations can be seen.

Another source of variation in the wave tracings is illustrated in Figure 3. During diastole a point at the left border of the heart not only moves laterally but downwards. Therefore at the end of diastole, point A, which was situated at the level of the slit, moves downward to occupy position A′; B′, which was situated above A at the beginning of the movement, is now at the level formerly occupied by A. From this it is apparent that a wave tracing here is composed of the movements of a series of points from A to B.

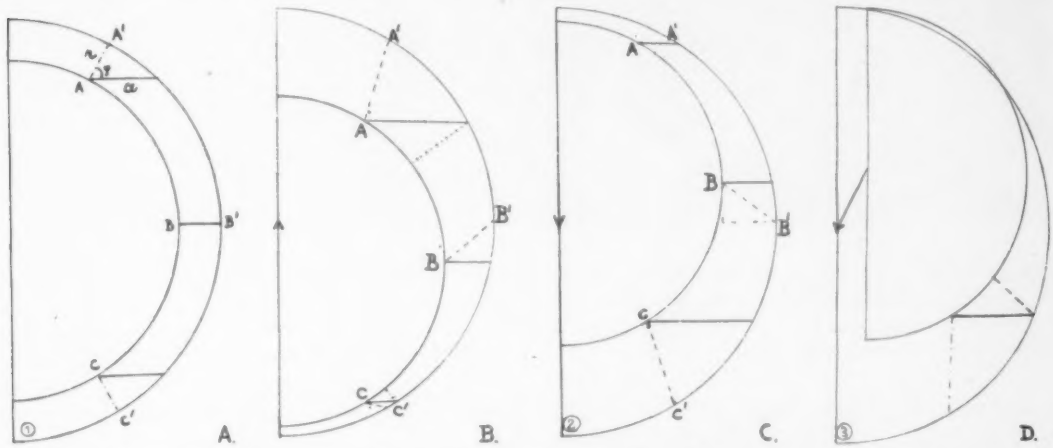

Fig. 1*A*. The concentric contraction of a sphere. Lines AA′, BB′ and CC′ represent the equal distance displacement of three different points on the circumference. The solid lines show how the movement would be recorded by the kymograph with horizontal slits. Only the line BB′ would be accurate (after Ludwig).

Fig. 1*B*. Contraction of a sphere with simultaneous downward movement. Lines AA′, BB′ and CC′ represent the actual displacement of three points. The solid lines show how the movement would be recorded on the kymogram through horizontal slits (after Ludwig).

Fig. 1*C*. Contraction of a sphere with simultaneous upward movement. On the kymogram the inaccuracies in displacement of points are similar to those described in Figure 1*B* (after Ludwig.)

Fig. 1*D*. Contraction of a sphere with simultaneous upward and lateral movement. On the kymogram no movement of the upper segment of the sphere would be recorded (after Ludwig).

PHYSIOLOGICAL VARIATIONS

Altered physiological conditions unassociated with disease may produce changes in the kymogram which simulate abnormalities of function and anatomy. Boehm and Ekert[2] were able to show alterations in the wave tracings varying from the formation of broad plateaus at the end of the lateral movements of the heart borders to complete obliteration of the waves in a large part of the cardiac contour (Fig. 4). The authors also describe "splintering" of the waves and alterations of the size and shape of the heart and great vessel area following a bath.

Striking changes in the size and contour of the heart were shown by Crowdin and

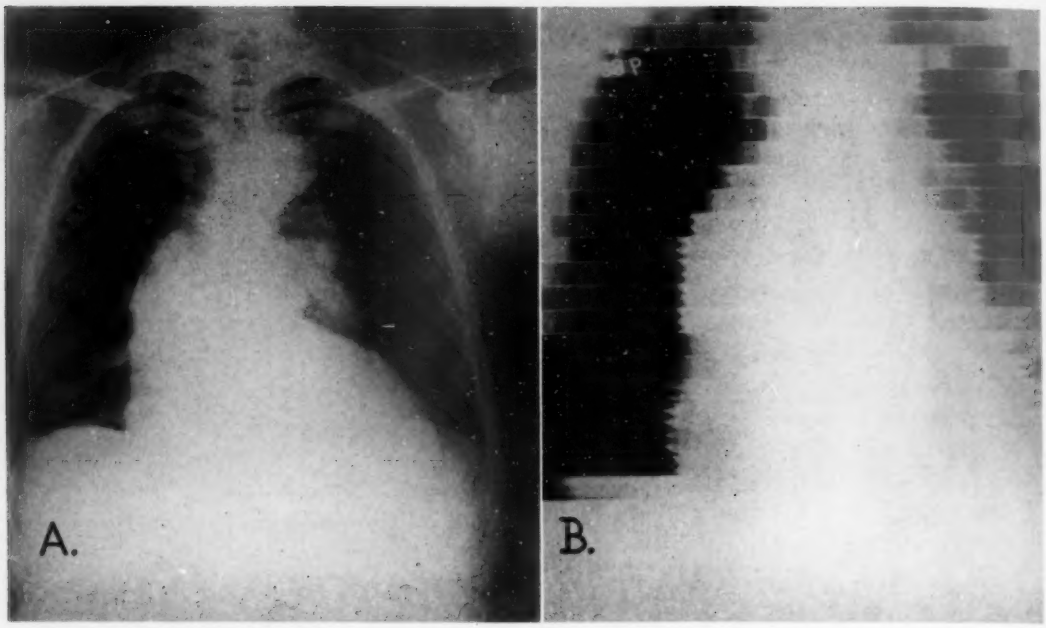

FIG. 2, *A* and *B*. Marked arteriosclerosis and tortuosity of the aorta. The kymogram shows movements of the aortic margins suggesting systolic expansion and diastolic contraction of the tube. At autopsy such marked sclerosis and rigidity were found that expansion and contraction of the walls could not have occurred. The recorded movements, therefore, represent lateral "uncoiling" movements of the arch.

Harris,[5] Roesler,[17] and Natvig[16] in Müller's and Valsalva's tests. In order to confirm

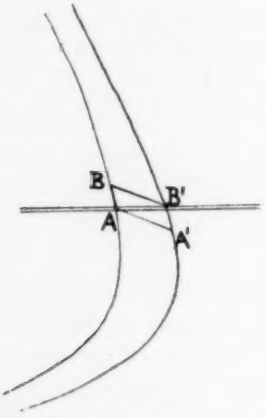

FIG. 3. Diagrammatic illustration of the downward displacement of a point on the heart border with diastole. Lines AA′ and BB′ represent the actual movement. Line AB′ shows the recorded movement but, instead of representing a single point, it is actually a series of points on the heart border.

their observations kymograms were made of a group of 14 patients first in a routine manner and then with forced expiration with the glottis closed. Ten showed a definite diminution in the size of the heart. Seven showed a reduction in the amplitude of the wave tracings at both heart borders. Alterations in the wave tracings of the aorta were equivocal. Moberg[15] showed that these changes can be attributed to increased intrathoracic pressure. He pointed

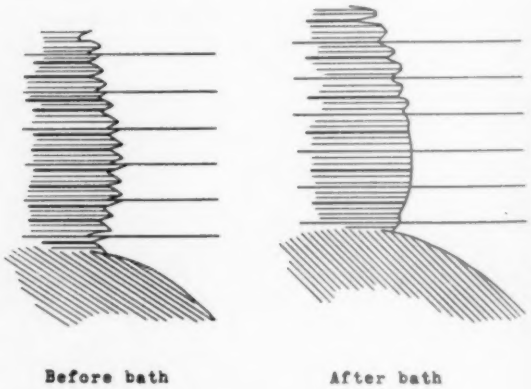

FIG. 4. Diagrammatic sketch of a kymogram of a segment of the left heart border showing the effect of a bath on the character of the wave tracings (after Boehm and Ekert[2]).

out that an increase in intrathoracic pressure of only 10 mm. Hg over a period of five seconds was sufficient to produce these alterations. Not infrequently in a routine examination when the patient is asked to hold his breath in deep inspiration, he closes his glottis and the air column is pressed against it, thus increasing the intrathoracic pressure. Similarly if asked to hold his breath at the end of expiration he unconsciously performs the Müller test by attempting to inspire with the glottis closed. This also produces changes in the cardiac contour. Another factor to be considered in evaluating the alterations in the wave tracings is the changed direction of pulsation as the result of the shift of the long axis of the heart toward the vertical with the descent of the diaphragm during inspiration (Ludwig[14]).

CLINICAL MATERIAL

In an attempt to appraise the clinical value of multiple slit roentgen kymography, 179 cases examined by this method were studied. In 16 cases, autopsy reports were available. The diagnoses in 3 cases were confirmed by operative procedures. The remaining cases were diagnosed clinically and by means of the electrocardiograph. Instances where the clinical diagnosis was in doubt were not included. The results are shown in Table 1. The term "diagnostic" has been used where the wave tracing has been typical and the diagnosis could be made from the kymogram alone. The term "compatible" has been used where the wave tracing was not inconsistent with the clinical diagnosis, but was not characteristic and would not by itself justify an independent diagnosis. It is worthy of comment that in some of the cases in this group the wave tracings could not be distinguished from the "normal" with any certainty, even in the presence of obvious disease.

Under the column designated as "equivocal" are included those kymograms which could not be correlated satisfactorily with the clinical and electrocardiographic findings.

Thirteen cases (7 per cent) showed kymograms which were typical enough to be diagnostic. These were found in pericarditis, adherent pericardium, advanced mitral disease and in myocardial infarction. Twelve of these cases presented typical clinical findings also and the kymograms served only as graphic records. In one case of coronary thrombosis where the electrocardiographic findings were equivocal, the roentgen kymogram showed absent wave tracings in one of the frames at the left heart border suggesting infarction. Instances of this have been mentioned by Gubner and Crawford[7] and Sussman, Dack and Master.[23] Sussman, *et al.*[23] found that 75 per cent of a series of 200 cases of myocardial infarction showed kymographic evidence of this lesion. They also called

TABLE I

	Diagnostic	Compatible	Equivocal	Total
Arteriosclerotic heart disease	0	12	1	13
Cardiac enlargement	0	8	2	10
Aortic insufficiency	0	4	3	7
Pulmonary stenosis and insufficiency	0	0	1	1
Coronary thrombosis	2	2	4	8
Congenital heart disease	0	4	1	5
Hypertensive heart disease	0	16	1	17
Pericardial effusion	3	1	0	4
Pericarditis—adherent pericardium	3	10	1	14
Rheumatic heart disease	5	36	2	43
Anginal state	0	2	0	2
Aortic aneurysm	0	14	3	17
Controls	0	25	6	31
Auricular fibrillation	0	0	4	4
Pulmonary artery aneurysm	0	1	0	1
Idiopathic myocarditis	0	1	0	1
Paroxysmal auricular tachycardia	0	1	0	1
	13	137	29	179

attention to the fact that a normal kymogram does not necessarily rule out the presence of an infarct and that an interval of three weeks may elapse before changes appear. We believe that the roentgen kymogram may provide information of some value in this type of lesion.

In 137 cases (77 per cent) the tracings were found to be compatible with the clinical diagnosis although not diagnostic in themselves. In patients with the same clinical diagnosis, variations in the character of the waves were quite marked. One cause for this is to be found in the gradations in the severity of the disease. For example, in mitral disease the valvular lesion may be minimal without demonstrable left atrial enlargement, or the disease may have progressed to advanced stenosis and insufficiency of the valve complicated possibly by involvement of other valves. Furthermore, when mitral insufficiency and mitral stenosis coexist, the wave tracing is influenced by either the predominance of the stenosis or insufficiency (Hirsch and Gubner[9]). Still another factor which must be taken into consideration is that the characteristic dynamic changes in mitral stenosis which greatly influence the contours of the wave tracings occur only after considerable narrowing of the mitral valve has taken place (Wiggers[24]). The enlarging left atrium can usually be seen before this occurs (Sosman[20]). The outward movement of the aortic wave, as pointed out by Wiggers, is likewise subject to the dynamic changes present at the moment. The amplitude and shape of these waves depend upon the degree of compensation or decompensation present at the moment.

Wave tracings of the aorta in syphilitic aortitis, arteriosclerotic heart disease and hypertensive cardiovascular disease showed no consistent characteristics. In syphilitic aortitis 3 cases showed an increase in the amplitude of the waves at the base of the aorta; 3 cases showed waves of average amplitude and in one case the waves were too poorly defined to be diagnostic. Eight cases of hypertensive heart disease showed no waves at the base of the aorta; 7 cases showed waves of average amplitude which could not be distinguished from the wave forms of average amplitude in luetic aortitis. No relationship could be established between the degree of the hypertension and the amplitude of the waves. Six of 10 cases of arteriosclerotic heart disease showed no lateral movements of the ascending aorta. Four cases showed distinct movements. These findings are essentially in accord with the views expressed by Stumpf, Weber and Weltz[22] and Scott, Moore and McCordock.[19]

Kymograms made in 4 cases of auricular fibrillation did not show any irregularity in the ventricular waves. Because of the short exposure time in making the kymogram, the finding of an irregularity is purely fortuitous.

In 1938 Blakemore and King[1] reported a series of cases of aortic aneurysms treated by a new technique of electrothermic coagulation which they devised. This consists of inserting a fine insulated metallic wire into the aneurysm and heating it by an electric current to 80° C. A heat inflammation takes place within the sac wall causing the formation of an adherent clot. With the formation and subsequent organization of the clot a reduction in the amplitude of the pulsations of the aneurysm could be expected. It is of interest that in several of the cases kymographic tracings before operation showed no evidence of movement of the margins of the sac. Since the publication of Blakemore and King's article kymograms were made in a number of cases in which marginal movements had been previously recorded, with the hope that this method would show graphically an obliteration or a significant diminution in the amplitude of the wave tracings at the borders of the aneurysm. There was, however, surprisingly little alteration of the wave contours in the kymograms. Autopsy reports are available in 2 cases in which postoperative kymograms were obtained. Despite extensive organized clots which occupied 50 to 85 per cent of the aneurys-

mal sacs, in neither instance was the tracing changed. These marginal movements are apparently caused by the shift of the aorta as a whole. Extensive clots were demonstrated in 2 other cases by means of arteriograms. In one of these the waves appear to have been diminished slightly in amplitude. Our experience with the use of the roentgen kymogram as an indication of clot formation in the treatment of aneurysms has thus far been disappointing.

SUMMARY

For the purpose of investigating the usefulness of roentgen kymography in the diagnosis of heart disease, a study was made of 179 unselected cases in which this method was used. In only 13 instances were the tracings of such a character that a diagnosis could have been made from them alone. In some cases with obvious heart disease there was no recognizable alteration from the normal as far as the recorded movements were concerned. Because of the gradations of heart disease, the inherent weaknesses of the method itself and the alterations in the wave tracings which occur on a purely physiological basis, the roentgen kymogram requires careful study, and interpretations must be made in the light of the clinical findings. In our experience the kymogram has been of only limited clinical value.

REFERENCES

1. Blakemore, A. H., and King, B. G. Electrothermic coagulation of aortic aneurysms. *J. Am. M. Ass.*, 1938, *111*, 1821–1827.
2. Boehm, G., and Ekert, F. Ueber die röntgenologisch fassbaren Einwirkungen von gewöhnlichen und therapeutischen Bädern auf die zentralen Kreislauforgane bei Herzgesunden. *Deutsches Arch. f. klin. Med.*, 1938, *182*, 598–610.
3. Boehm, W. Bewegungsstudien an den Binnenräumen von Herz und Gefässen. In Stumpf, Weber and Weltz, see ref. 22.
4. Crane, A. W. Roentgenology of the heart. Am. J. Roentgenol., 1916, *3*, 513–524.
5. Crowdin and Harris. Cited by Paul White in "Heart Disease." Macmillan Co., New York, 1937.
6. Gött, T., and Rosenthal, J. Ueber ein Verfahren zur Darstellung der Herzbewegung mittels Röntgenstrahlen (Röntgenkymographie). *München. med. Wchnschr.*, 1912, *59*, 2033–2035.
7. Gubner, R., and Crawford, J. H. Roentgenkymographic studies of myocardial infarction. *Am. Heart J.*, 1939, *18*, 8–24.
8. Hirsch, I. S. Recording of cardiac movements and sounds by the roentgen ray (kymophonoroentgenography). *Radiology*, 1934, *22*, 403–422.
9. Hirsch, I. S., and Gubner, R. Application of roentgenkymography to the study of normal and abnormal cardiac physiology. *Am. Heart J.*, 1936, *12*, 413–434.
10. Hitzenberger, K., and Reich, L. Ein Beitrag zur Röntgenkymographie. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1923–1924, *31*, 17–18.
11. Johnson, S. E. Roentgen kymography considered in relation to heart output, and a new heart index. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 167–174.
12. Keys, A , and Friedell, H. L. Measurement of heart size with the roentgenkymograph. *Proc. Soc. Exper. Biol. & Med.*, 1939, *40*, 267–270.
13. Knox, R. Cardiac diagnosis a survey of the development of physical methods. *Proc. Roy. Soc. Med.* (*Sect. Electroth.*), 1922–1923, *16*, 1–30.
14. Ludwig, H. Negatives und Positives von der Herzkymographie. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1936, *54*, 469–476.
15. Moberg, G. Some views on the important part played by pressure conditions in chest and abdomen for radiographic examination of heart and lung. *Acta radiol.*, 1940, *21*, 1–20.
16. Natvig, P. Volume of the heart in Müller's and Valsalva's tests. *Acta radiol.*, 1934, *15*, 657–658.
17. Roesler, H. Clinical Roentgenology of the Cardiovascular System. Charles C Thomas, Springfield, Ill., 1937.
18. Sabat, B. Ueber ein Verfahren der röntgenographischen Darstellung der Bewegungen des Zwerchfells, des Herzens, der Aorta. *Lwow. tygodn. lek.*, July, 1911, No. 28, 4. Republished in *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1913, *20*, 42–44.
19. Scott, W. G., Moore, S., and McCordock, H. A. Roentgen kymographic studies of cardiac conditions. *Radiology*, 1937, *28*, 196–210.
20. Sosman, M. C. Roentgenological aspects of acquired valvular heart disease. Am. J. Roentgenol. & Rad. Therapy, 1939, *42*, 47–59.
21. Stumpf, P. Das röntgenographische Bewegungsbild und seine Anwendung. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Ergänzungsband 41.) Georg Thieme, Leipzig, 1931, pp. 1–78.

22. STUMPF, P., WEBER, H. H., and WELTZ, G. A. Röntgenkymographische Bewegungslehre innere Organe. Georg Thieme, Leipzig, 1936.
23. SUSSMAN, M. L., DACK, S., and MASTER, A. M. Roentgenkymogram in myocardial infarction. *Am. Heart J.*, 1940, *19*, 453–463.
24. WIGGERS, C. J. Physiology in Health and Disease. Lea & Febiger, Philadelphia, 1934.

DISCUSSION ON PAPERS BY DRS. RIGLER, WANGENSTEEN AND FRIEDELL, SCOTT, AND FRIEDMAN

DR. SAMUEL A. LEVINE, Boston. As I listened to the papers and read the abstracts before coming here, the thing that I asked myself and ask the roentgenologists really is: How much would be missed by careful fluoroscopy? That is important from the point of view of expense. I am in no position to answer that, but I get the impression that very little would be missed except as a comparison was made for study.

The recent development of kymography is important. All new observations lead to something whether it be observations of the curvature of the nails, or color of the lips. We have learned something about the significance of changes in nails, a rather inconspicuous thing to study. And likewise some good must come out of the work that roentgenologists are doing in kymography, and we already see the results.

How much good the roentgenologists will do will depend upon how good the clinician is who is engaged in the work. A good clinician needs the roentgenologist much less than does a poor clinician. This applies particularly to heart disease. I should like to emphasize one very important point very forcefully here and take issue with the statement Dr. Scott made. It isn't challenging him in his field. A diagnosis of angina pectoris is made clinically and then, when it is made, the clinician shouldn't care what the roentgenologist or anybody else says. The diagnosis of angina pectoris is not made by ruling other things out. The diagnosis is made by the history and then when it is done properly, it doesn't matter what else is present in that patient, whether the kymogram shows one thing or another, or the roentgenogram shows a peptic ulcer, or spondylitis; people can have more than one disease, and a patient with angina pectoris very frequently has other diseases, particularly gallbladder disease.

The kymogram can't possibly make a diagnosis of angina pectoris. It is the diagnosis of a state, not of a structural abnormality. The kymogram could make a diagram of injury to the heart muscle; that occurs frequently. We have had a fair number of bona fide cases of angina pectoris in which the roentgen examination, the kymogram, too, were perfectly normal. The heart contractions were just as normal in contour and every other respect, as any other heart. If the patient has this lethal disease we call angina pectoris, the kind that will frequently show myocardial infarction with a tendency to sudden death, the condition is not measurable in terms of roentgenology.

The cases we heard Dr. Rigler describe to us are extraordinary. They are wonderful, and the roentgenologist is going to help a great deal in detecting such cases with constrictive pericarditis. It is well to keep watch for constrictive pericarditis among supposed cases of cirrhosis of the liver or tuberculous peritonitis. When the physician makes or suspects such a diagnosis, the roentgenologist is put on his guard and can help a great deal, just as he often makes the diagnosis of pulmonary tuberculosis in cases that the clinician sends to him for gastrointestinal roentgen study. Likewise you may do the same thing in other cases in which the clinician doesn't even think of heart disease. Nowadays I think a good cardiologist initiates the study, for the most part, but when one isn't that well trained, the diagnosis may be initiated by the roentgenologist.

I welcome, as we all do, this splendid work that the roentgenologists are doing in heart disease; it is such a contrast to the situation eighteen or twenty years ago and we can look forward to great improvement in our diagnostic accuracy in years to come.

DR. L. HENRY GARLAND, San Francisco. Through the kindness of the authors, it was my privilege to read the papers of Drs. Rigler, Wangensteen and Friedell, Dr. Scott and Dr. Friedman prior to their presentation, and I shall attempt to discuss them in that order. Dr. Rigler has demonstrated in his usual thorough manner the value and limitations of cardiac roentgen kymography in the diagnosis of adherent pericardial scar and constrictive pericarditis. I agree with his conclusions as to the value of kymography in differential diagnosis and in providing a permanent record of cases of generalized or extensive adherent pericardial scar. However, I cannot agree that "localized areas of constriction exhibit themselves readily." Limi-

tation of movement of two or three frames on the left side of the heart, especially near the apex, may occur in normal individuals on deep inspiration. Localized diminution of pulsation elsewhere may be due to infarction. Therefore, I do not understand how the diagnosis of localized areas of constriction can be made readily, and I must regard the correct diagnosis which he achieved in Case III as purely fortuitous! The occasional great value of the normal kymogram is vividly illustrated by his Case VI, the young man who developed a bizarre form of constrictive pericarditis while under medical observation. I believe the main value of kymography in cases of suspected constrictive pericarditis lies in the differential diagnosis of atypical cases and as a means of permanent record in others.

With most of Dr. Scott's conclusions I am in hearty agreement. It is said that about 15 per cent of patients with cardiac infarction have normal electrocardiographic records. It is in these 15 per cent that we would like to demonstrate the usefulness of roentgen kymography. Dr. Scott reports 3 cases in which electrocardiographic findings were equivocal or lacking, but in whom roentgen kymographic findings were positive for infarction. This is very encouraging, but he wisely adds, "Do not get the impression that this is the rule; the superior value of the electrocardiograph is unquestioned." It has been our impression that the roentgen kymogram is of very slight value in localizing the *site* or *extent* of the infarct; however, we would like to make further autopsy studies before controverting Dr. Scott's remark that the kymograph is frequently of help in localizing such infarcts.

The alterations of the wave patterns which occur on a purely physiological basis are well emphasized by Dr. Friedman in his critical review. I suppose that all of you who have roentgen kymographs have performed the simple experiment of making daily roentgen kymograms on a given healthy individual for six or seven days, and a similar set on a given cardiac case (for example, a mitral insufficiency). If not, I can recommend it highly. Even cooperative and intelligent medical students occasionally perform an unconscious Valsalva test on themselves during routine examination. Apprehensive, heart conscious patients are all the more apt to do so. Inexplicable variations in the shape and amplitude of the various waves will be noted in normal, as well as abnormal individuals, from day to day, rendering detailed pathological conclusions based on the shape of such waves highly inaccurate. One is reminded of the pathological labels applied to perfectly normal colons by physicians not familiar with the extraordinary variability of the roentgen appearance of the normal colon. Dr. Friedman's observations on the presence of apparent pulsations in aneurysms containing large laminated thrombi are noteworthy. Both Scott and Friedman emphasize that the criteria for the diagnosis of infarction are still not entirely satisfactory; conversely, I have seen a few instances of pseudo-infarct (two or three silent frames) in normal individuals.

In spite of the complexity of the mechanism of cardiac pulsation, I believe it is possible to measure cardiac size and stroke output by the method of Keys and Friedell, although the method does require considerable diligence and reasonable experience for reproducible results. It is not improbable that the great value of roentgen kymography will lie in such physiological or physiopathological work. Its value in the diagnosis of myocardial infarction, cardiac aneurysm and constrictive pericarditis is noteworthy, but it is not the precision method which some of us at least had anticipated. Its value in the differential diagnosis of mediastinal tumors, aneurysms and so forth has been shown to be very limited. We owe a debt of gratitude to Drs. Rigler, Scott and Friedman for the large amount of material which they have analyzed so carefully.

Dr. Merrill C. Sosman, Boston. I should like to emphasize again, in case you have gotten a misconception, that this is not a private fight. In his work Dr. Scott is honestly attempting to evaluate the usefulness of the roentgen kymographic method. I feel, as Dr. Levine said, that probably the best way to estimate its usefulness is to see whether we might have missed something if we had not used the kymogram, and I would carry it one step farther than he did, that is: How many errors would we make when we use the kymogram in addition to fluoroscopy? I think that is one of the biggest factors that has not been considered yet. There are a great many so-called "silent frames" easily mistaken as indicating an infarct, which must be ruled out by fluoroscopic observation.

Does anyone have any testimony on this matter which he wants to bring before the court of radiology? Dr. Sussman, have you had any experience with this?

DR. M. L. SUSSMAN, New York City. I think we should differentiate a bit between the various reasons for doing kymography. It is sure that most observations on diminished pulsations can be made fluoroscopically. Also, there is no question that you can see paradoxical pulsations in myocardial infarction on fluoroscopic examination. The question still remains however: What can kymography offer that other methods perhaps cannot?

We have studied 200 cases of clinical coronary thrombosis, many from the acute phase into the healed stage. Master and his associates studied practically the same group fluoroscopically and in 50 per cent they were able to demonstrate paradoxical pulsation fluoroscopically. By kymography we were able to recognize this abnormality in 75 per cent. These percentages refer to unequivocal paradoxical pulsation.

There is no question that Dr. Friedman is perfectly correct. You can produce all sorts of peculiar changes in the pulsation form experimentally. The question is: Are there any definite changes that cannot be produced by the various physiological experiments? We think that a paradoxical pulsation, or a diminution of pulsation localized to one or two intervals with normal or nearly normal pulsation above and below, cannot be produced by physiological means and if you apply those rigid criteria before you make the diagnosis, then I think you are likely to be right.

Furthermore we have had in the past year at least six cases in which serial electrocardiograms have been normal and in which the roentgen kymogram has been positive. As Dr. Levine says, usually you can make the diagnosis of coronary occlusion clinically, but the clinician ordinarily prefers confirmatory evidence. If the serial electrocardiograms have been negative, and the kymogram is positive, I think the examination has been of value.

The kymogram obviously does not replace the electrocardiogram. It is a further confirmatory procedure. I think it is very significant that at the Mount Sinai Hospital the number of kymograms that are being ordered in cases of questionable coronary thrombosis is increasing materially.

DR. RIGLER (closing). I should like to make a few additional observations. Dr. Garland, in his usual manner, put his finger on one of the difficulties of the problem. The diagnosis of localized constrictive areas might be called fortuitous if you did not take into consideration that we, in making our diagnoses, have considered somewhat the clinical situation. In this localized area absent pulsation was first observed fluoroscopically. I don't know whether I made that clear. We were, nevertheless, fortified by the roentgenogram.

If you fluoroscope a heart today and then tomorrow, and then next week, you may not be very certain that the area of absent or abnormal pulsation is the same as you saw the first time, but if you have a series of films of kymograms to sit down and examine at leisure, I think you have a great advantage.

Here was an eight-year-old girl. The chances of myocardial infarct were rather remote. She had many evidences to suggest venostasis and a persistent localized area of absent motion shown on repeated roentgen kymograms over a period of a month. This constant absence of pulsations does not occur in the normal cases to which Dr. Garland referred.

Dr. Levine mentioned the point about finding the cases coincidentally. The last case I showed came in because of a foreign body in the eye, yet on close study of the history, after the roentgen diagnosis was made, we found evidence of dyspnea and other findings which indicated that some degree of venostasis was present, a thing overlooked in the first instance. I think that may happen more often than is thought.

There is one more thing I should like to mention, and that is the question of the so-called Keys and Friedell method for studying the output of the heart, which we presented to this Society last year. There have been four essential criticisms of this method, I should say.

The first one Dr. Friedman brought out; i.e., the effect of a changing intrathoracic pressure upon the pulsations of the heart. That is a very valid criticism but by reasonable care and some training of the patient, with rare exceptions, the Valsalva or Müller effect can be avoided.

Second, there is the pendulum motion of the heart, which Dr. Friedman again brought out. This can be easily eliminated because if you measure the entire cardiac area, the pendulum motion cancels itself out and it is not a serious factor in the systolic or diastolic size of the heart.

Third is the point that Dr. Sosman made last year, that septal movements are not taken into account. That is most easily answered by pointing out that physiologic investigators have

measured the output of the heart by putting a rubber bag around the exposed heart of a dog. The septal movement is entirely ignored yet they get very accurate results. That is what you would expect because the septal movement only affects the distribution of blood within the heart, but not the output of the heart as a whole.

The fourth criticism, which Dr. Friedman brought out, is the most crucial; that is, the cephalocaudad movements of the heart are undoubtedly a factor which cannot be measured in this way. The only answer we have is that a comparison of the stroke output as calculated by this method with that calculated by the acetylene method shows the incidence of error to be relatively small; so small, it seems inevitable to conclude there is a correlation. Whether or not there has to be a correlation is another question, but it doesn't necessarily have to be wrong, and one can only answer that by the empirical result which has been achieved.

Dr. Scott (closing). I am very much pleased to have had the compliment of Dr. Levine's discussion of our paper. In answer to his first questions as to the information afforded by fluoroscopy and whether or not the patients are examined fluoroscopically before taking the kymograms, I will say that the only cases that come to the Roentgen Department for kymography are those which the internist or cardiologist has already fluoroscoped, frequently with his own equipment, and in which he has been unable to obtain all the desired information about that particular patient. The patients with easy or obvious diagnostic problems are not referred for fluoroscopic study and kymograms because the services of the Roentgen Department necessitate an added expense to the patient. Therefore, the cardiac patients that we are called upon to examine usually present the more difficult problems in diagnosis. I think this is the way kymography should be employed. The internist or cardiologist should use every diagnostic means available first, and then, if the problem is not completely understood, or he desires a permanent record of the cardiac movements, kymography may provide additional help. Many times it will not, and for that reason kymography should be reserved for selected cases.

I acknowledge Dr. Levine's objection to my use of the terms, *angina pectoris* and *coronary artery disease*, interchangeably. Since he considers angina pectoris a distinct clinical entity without associated coronary artery change, we cannot diagnose angina pectoris from the kymogram, and we should report our findings as being compatible with coronary artery disease.

I understand his view that a poorly trained internist or cardiologist can be greatly aided in his examination of the patient by an astute roentgenologist. Likewise an inadequately trained roentgenologist cannot be of much help to an expert cardiologist. The ideal result is achieved by a cooperative work, each supplementing the other.

Dr. Garland's discussion was very keen and to the point. I am grateful to Dr. Sussman for giving us his experience in the diagnosis of cardiac infarction.

Dr. Friedman (closing). I want to thank the discussers for their comments. In our series the number of cases of coronary occlusion and cardiac infarct was too limited to draw any definite conclusions. Nevertheless, we feel as Dr. Sussman does, that the kymogram may be of considerable value in these conditions.

CARDIAC ROENTGENOLOGY

THE VALUE OF EXACT CARDIAC MEASUREMENTS*

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IN THE diagnosis of cardiac disease, a thorough history and physical examination are of primary importance. In addition to this, careful roentgenoscopy and teleroentgenography are often of decided assistance. However, these, as well as other laboratory procedures, are merely accessories to the clinical examination of the patient, and overdependence upon laboratory measures, especially that of cardiac mensuration, is to be deplored.

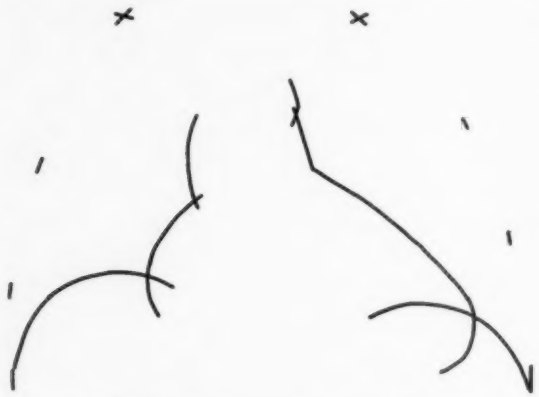

FIG. 1. Case 288. Transverse diameter of heart, 14.5 cm.; transverse diameter of chest, 23.0 cm.; cardiothoracic ratio, 63 per cent. Normal heart.

In the roentgen examination of the heart, the *shape* of the silhouette is of much greater importance than any of the measurements. It is not within the scope of this paper to discuss the various cardiac silhouettes obtained as the result of various lesions. This information is factual and may readily be obtained.[7,8] It should be mentioned here, however, that roentgen examination at its best is often faulty when compared with autopsy findings.[3]

It is common practice in many departments of roentgenology to report the cardiac silhouette as being abnormally enlarged because the cardiothoracic (C-T) ratio is over 50 per cent.[2,5,6] It is felt that this practice is erroneous and the following evidence is presented in support of this belief.

A series of cases were studied by the usual clinical and laboratory methods. The orthodiagrams were obtained by accepted technique,[1] the patient breathing quietly and the diaphragm being in its cephalad position when the sketch was made.

The series consisted of 355 cases (Table 1), 198 of which were normal and 157 of which showed definite evidence of cardiac pathology. Of the normal cases, 74 (37 per cent) had a cardiothoracic ratio greater than 50 per cent; of these 20 (10 per cent) were greater than 53 per cent, this figure being regarded as top normal by some workers.[2,6]

The greatest cardiothoracic ratio in a normal individual was 63 per cent. This (Fig. 1) was in the case of a nurse, aged twenty-seven, who, as far as could be determined by thorough examination, was in perfect health. However, she was of the type with a short, broad chest and, in addition, was obese. These factors caused the diaphragm to assume a high position. These findings were discovered upon routine physical examination as the girl had no symptoms whatsoever. Repeated blood pressure estimations were normal. Roentgenoscopically, her cardiac silhouette assumed a more normal configuration upon deep inspiration, this being due to a lowering of the diaphragm.

All of the normal cases in which the cardiothoracic ratio was greater than 50 per cent were persons with, or a tendency toward, an elevated diaphragm or other conditions causing a relatively short, broad chest.

On the other hand, there were 34 (22 per

* Study conducted at the Heart Station, Rhode Island Hospital, Dr. Frank T. Fulton, Director.
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cent) of the clinically abnormal cases in which the cardiothoracic ratio was less than 50 per cent. This, however, is of less practical significance because while an enlarged heart is assumed to be pathological until proved otherwise, it is well known that a diseased heart may be normal in size.

Two of these abnormal hearts with normal cardiothoracic ratios are of interest.

The first (Fig. 2) is that of a married woman, aged twenty-nine, with two living children. She had a positive history of rheumatic fever in childhood and had been followed for seven years as a definite clinical case of rheumatic heart disease with mitral stenosis and regurgitation. This patient is presented because of the long period

Fig. 2. Case 238. Transverse diameter of heart, 11.0 cm.; transverse diameter of chest, 22.5 cm.; cardiothoracic ratio, 49 per cent. Typical silhouette of mitral stenosis.

during which the presence of mitral stenosis was recognized, the typical silhouette of this condition, and yet a cardiothoracic ratio of only 49 per cent.

The second (Fig. 3) is that of a housewife, aged twenty. Eight years ago she had a definite attack of rheumatic fever because of which she was confined to bed for three years. Upon convalescence, she married, became pregnant and was delivered with no difficulty. She was first brought to our attention near the close of her second pregnancy at which time a murmur of mitral stenosis was detected. She was watched closely and the pregnancy terminated normally. One month postpartum

Fig. 3. Case 338. Transverse diameter of heart, 11.2 cm.; transverse diameter of chest, 22.5 cm.; cardiothoracic ratio, 50 per cent. Normal cardiac silhouette. This patient had a definite mitral stenosis and insufficiency plus subacute bacterial endocarditis. This illustrates the point that, even at best, the roentgen examination of the heart is not entirely dependable.

she developed pain, swelling, and redness of her ankles, knees, and elbows. One week later, upon admission to the hospital, she was complaining only of pain in one wrist which subsided the same day without treatment. However, at that time she showed a daily fever reaching 103° F. each afternoon. She had numerous petechiae and a blood culture showed 197 colonies of *Streptococcus viridans*. She had definite systolic and presystolic murmurs at the apex.

This case is presented because of the cardiac silhouette (Fig. 3) made six weeks prior to admission. This was normal in all respects as was the roentgenoscopic examination. The esophagus was not deviated from its normal course. A teleroentgenogram taken during the present admission showed no significant change, the silhouette being well within normal limits. This case,

with its marked pathology, had, like the preceding case, a normal cardiothoracic ratio. However, in addition, and more important, the shape of the silhouette was well within normal limits. There was no evidence of enlargement of any chamber of the heart.

It has been demonstrated elsewhere[1] that the value of the cardiothoracic ratio as obtained by the technique used in this study is different from the value as obtained by teleroentgenography. The reasons for this cannot be fully discussed here but in brief it is due to two facts: (1) the usual chest roentgenogram is taken with the patient holding his breath in inspiration which causes the diaphragm to assume its lowest position; (2) there is a small, but appreciable, magnification of the silhouette as produced by the 7 foot plate. There is, in addition, a greater magnification of the interthoracic measurement. This causes a definite difference in the cardiothoracic ratio. However, this difference has been shown to be small and is constant in that the value as obtained by teleroentgenography is always smaller than that obtained by orthodiography.

In the present series, it is shown that if values in excess of 50 per cent are to be considered abnormal, there is an error of 37 per cent in comparison with the data obtained by other methods. If the limit is raised to values exceeding 53 per cent, the error is reduced to 10 per cent.

Hodges and Eyster[4] prepared prediction tables based upon formulae considering the age, height, and weight of the subject. They found these tables to be only 19 per cent efficient, which means that they are 19 per cent more efficient than assuming an average for all cases or, in other words, are

Table IA

CLINICALLY NORMAL CASES

Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent
1	49	27	49	52	45	77	53	102	47	127	45	152	43	177	53
2	42	28	53	53	50	78	52	103	43	128	50	153	47	178	47
3	42	29	46	54	46	79	54	104	42	129	51	154	47	179	52
4	42	30	52	55	47	80	49	105	47	130	46	155	56	180	50
5	47	31	48	56	50	81	52	106	51	131	49	156	42	181	51
6	48	32	49	57	52	82	52	107	48	132	51	157	51	288	63
7	44	33	47	58	50	83	50	108	48	133	51	158	49	289	50
8	51	34	48	59	50	84	45	109	49	134	51	159	50	290	51
9	49	35	51	60	51	85	51	110	52	135	45	160	55	299	46
10	54	36	48	61	49	86	46	111	48	136	46	161	49	301	52
11	46	37	53	62	50	87	46	112	48	137	43	162	52	302	54
12	51	38	52	63	53	88	53	113	43	138	53	163	52	303	49
13	52	39	46	64	43	89	48	114	47	139	48	164	51	304	46
14	51	40	50	65	48	90	48	115	51	140	42	165	51	305	53
15	52	41	48	66	57	91	50	116	53	141	48	166	51	306	49
16	50	42	44	67	50	92	40	117	54	142	46	167	47	307	58
17	48	43	44	68	46	93	52	118	51	143	52	168	47	308	49
18	47	44	58	69	47	94	46	119	42	144	51	169	52	309	48
19	44	45	44	70	48	95	55	120	50	145	42	170	50	310	54
20	46	46	51	71	43	96	54	121	54	146	49	171	47	311	46
21	53	47	44	72	46	97	50	122	46	147	47	172	51	312	52
22	53	48	45	73	50	98	48	123	51	148	56	173	50	313	52
24	50	49	49	74	47	99	54	124	49	149	46	174	49	314	55
25	51	50	48	75	43	100	52	125	43	150	45	175	41		
26	55	51	46	76	54	101	53	126	47	151	46	176	52		

TABLE IB

CLINICALLY ABNORMAL CASES

Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent	Case No.	C-T Ratio per cent
23	59	206	55	231	55	256	65	281	54	324	52	349	50
182	59	207	61	232	69	257	54	282	47	325	56	350	52
183	50	208	52	233	61	258	55	283	54	326	57	351	61
184	55	209	60	234	60	259	53	284	69	327	50	352	44
185	55	210	45	235	46	260	56	285	53	328	68	353	49
186	46	211	67	236	66	261	72	286	52	329	67	354	48
187	60	212	52	237	58	262	53	287	52	330	66	355	52
188	55	213	59	238	49	263	50	291	43	331	48		
189	48	214	61	239	52	264	61	292	45	332	47		
190	55	215	53	240	54	265	47	293	56	333	61		
191	64	216	54	241	59	266	48	294	58	334	52		
192	62	217	47	242	57	267	59	295	65	335	55		
193	51	218	55	243	47	268	51	296	68	336	58		
194	53	219	50	244	53	269	55	297	53	337	58		
195	55	220	61	245	50	270	52	298	63	338	50		
196	65	221	56	246	66	271	55	300	59	339	59		
197	55	222	51	247	46	272	82	315	44	340	56		
198	53	223	57	248	54	273	51	316	56	341	53		
199	54	224	61	249	47	274	57	317	45	342	53		
200	50	225	47	250	59	275	56	318	64	343	64		
201	53	226	66	251	71	276	62	319	46	344	57		
202	52	227	60	252	54	277	56	320	62	345	53		
203	56	228	57	253	57	278	60	321	52	346	69		
204	53	229	56	254	60	279	48	322	53	347	57		
205	56	230	50	255	59	280	62	323	52	348	49		

only a slight improvement over random guessing.

As a whole, the cardiothoracic ratio is unreliable as an index of cardiac abnormality. It is felt that too much stress is being placed upon cardiac measurements, especially the cardiothoracic ratio. The greatest amount of information obtainable from the roentgenologic study of the heart is the *configuration* of the cardiac silhouette. This is best obtained by a careful roentgenoscopic study with visualization of the esophagus followed by an orthodiogram or a teleroentgenogram. As such, and used only as an adjunct to clinical methods, the roentgen ray can be of great value in the diagnosis of heart disease.

REFERENCES

1. Clagett, A. H., Jr. The auriculoventricular ratio and its relationship to the electrical axis of the heart. *Am. Heart J.*, 1941, *21*, 574–591.
2. Danzer, C. S. The cardio-thoracic ratio; an index of cardiac enlargement. *Am. J. M. Sc.*, 1919, *157*, 513.
3. Epstein, B. S., and Schwedel, J. B. Correlation of the fluoroscopic, clinical, and post-mortem findings in 155 cases of organic heart disease. *Am. Heart J.*, 1938, *15*, 317–334.
4. Hodges, F. J., and Eyster, J. A. E. Estimation of transverse cardiac diameter in man. *Arch. Int. Med.*, 1926, *37*, 707–714.
5. Jacobs, I. E., and Worster, C. B. X-ray procedure and technique. *U. S. Nav. M. Bull.*, 1921, *15*, 524.
6. Martin, C. L. Roentgen ray cardiac studies. Am. J. Roentgenol., 1921, *8*, 295–315.
7. Roesler, H. Clinical Roentgenology of the Cardiovascular System. Charles C Thomas, Springfield, Ill., 1937.
8. Criteria Committee of the New York Heart Association. Nomenclature and Criteria for Diagnosis of Diseases of the Heart. Fourth edition. New York, 1939.

THE ROENTGENOGRAPHIC FEATURES OF PERFORATED INTERLOBAR ABSCESS (INTERLOBAR EMPYEMA)*

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ALTHOUGH infrequently encountered interlobar empyema is a serious lesion. A presentation of its roentgenographic features, as well as a brief reference to pathological and clinical aspects, is therefore justified. Treatment was described in another communication.[1] Sixteen cases of localized interlobar empyema, by which is meant interlobar pleural collections of pus entirely confined to the space between two lobes, were found among the case records of 650 cases of empyema treated at the Mount Sinai Hospital in the past ten years.

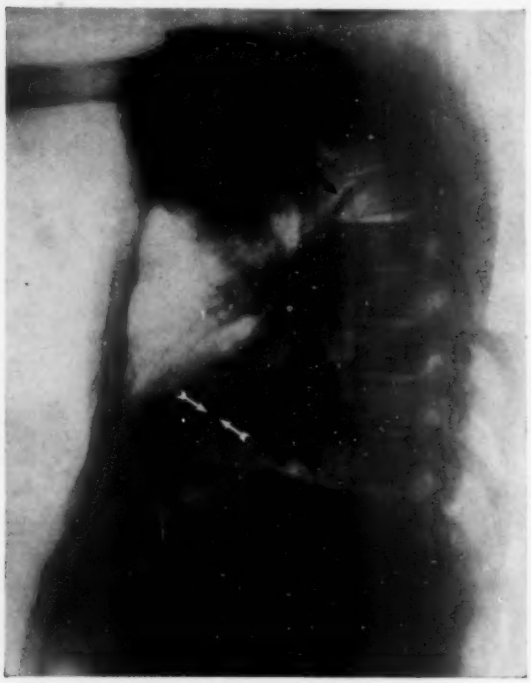

FIG. 1. Case III. Typical loculation of fluid and air within the upper portion of the long fissure (black arrow). The antero-inferior portion of the fissure is visualized because of pleural exudate (white arrows).

Since the recognition of the roentgenologic evidence depends on the determination of abnormal appearances in or about the interlobar fissures, a brief review of the normal anatomic arrangements of these fissures is warranted.

The long interlobar (oblique) fissure extends obliquely downward and forward from the level of the second dorsal spine to the sixth costochondral junction in the mid-clavicular line. On the right side, the short (horizontal) fissure starts from the long fissure in the mid-axillary line and extends anteriorly following the course of the fourth rib. It assumes a generally horizontal plane. On the right side, the interlobar spaces are bounded posteriorly and superiorly by the upper and lower lobes, anteriorly by the upper and middle lobes, and in the extreme anterior zone, but on a lower plane, by the middle and lower lobes. On the left side there is only one interlobar fissure (if no congenital variations are present), which traverses a course similar to that of the long fissure on the right.

Normally, except for the occasional appearance of the short fissure on the postero-anterior films, when paralleled by the central ray, the fissures are not seen.

The 16 cases on which this paper is based can be divided into those in which the roentgenological evidence suggested an interlobar lesion, and those in which the lesion was obscured or could not be identified.

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The following findings, one or more of which were present in 9 cases, point to a definite diagnosis of interlobar disease, or are sufficiently suggestive to warrant a consideration of such a diagnosis:

1. An interlobar collection of fluid, air, or both fluid and air (Fig. 1).

A homogeneous oval or elliptical shadow delimited by the interlobar fissures, or overlying the region of the fissures, was found in 2 of our cases to be due to loculated pus (Cases I and II). Where air alone was found between definitely identified interlobar pleural surfaces, the collapsed lung obscured the pus which was also present (Case IX). Fluid and air were found together in 2 cases (Cases III and IV) and the limiting margins were definitely identified as the interlobar pleura.

FIG. 2. Case IV. Collection of fluid and air in or abutting on a fissure.

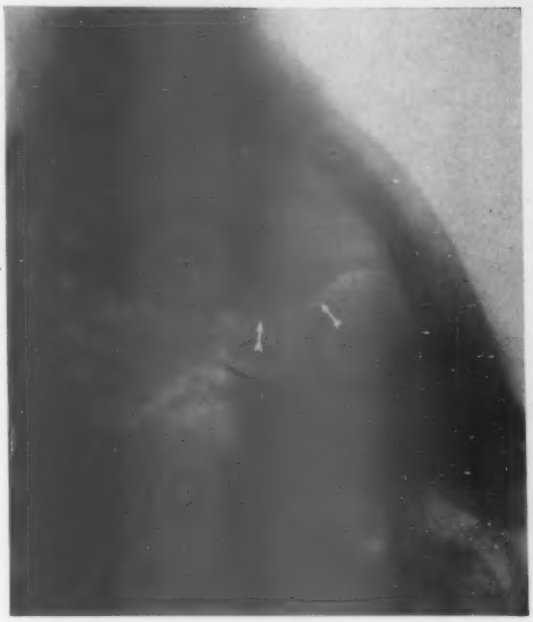

FIG. 3. Case VII. Bowing of the short fissure (arrows) by an interlobar collection of pus. The lower portion of the long fissure is also visualized because of pleural exudate.

2. A fluid level traversing a fissure or abutting on a fissure (Fig. 2).

The fluid level of the pyopneumothorax overlay the fissure, which was seen as a line of thickened pleura above and below the loculation (Case VI). In another case (Case V) one extremity of the fluid level appeared to begin at the fissure. The difference between these cases and those in the first group (Cases III and IV) is that the interlobar pleurae were not identified as the limiting membranes.

3. Bowing of a fissure (Fig. 3).

A large empyema so distended the interlobar space as to cause bowing of the limiting interlobar pleura (Case VII).

4. Progression of disease along a fissure (Fig. 4).

In one case (Case VIII), films made at intervals had shown extension of disease along a fissure. Since pulmonary infection usually spreads along a bronchial distribution, contiguous extension of infection should suggest pleuritis.

FIG. 4. Case VIII. Slight bowing of the mid-portion of the long fissure, with apparent extension of disease to the postero-inferior portion of the upper lobe.

The last three signs are not infallible, as cases have been seen in which these signs were found and in which operation proved the disease to be entirely intrapulmonary. Even a fusiform shadow in the known location of a fissure has been noted in a case in which the disease did not involve the pleura (Fig. 6). Only the presence of fluid and air loculated within interlobar pleural surfaces can be regarded as pathognomonic.

FIG. 5. Case XV. A circumscribed shadow in the left lung simulating a peripheral type of primary cancer of the lung.

FIG. 6. (Case not included in this study.) A case of pulmonary abscess without perforation into the pleura. However, not only is there a fluid level (white arrow) in or abutting on a fissure, but also an elliptical shadow (black arrows) overlying the lower portion of the long fissure. At operation, both lesions were intrapulmonary. The black line noted above the fluid level is an opaque marker placed in the lung through the previously operated site.

In 7 cases (44 per cent) there were no distinctive roentgenological signs. In 3 of these cases the hemithorax was obscured by a pleural effusion. In 2 other cases (in which lateral views were not obtained) there was no roentgenological evidence pointing to the pyopneumothorax which was later proved to be present. The appearance in Case XVI (Fig. 5) suggested a peripheral type of primary cancer of the lung.[2] The only clue to the possibility of lung abscess was the history of a recent dental operation.

The outstanding and constant feature of interlobar empyema at operation was a perforated lung abscess. In all but one case, the perforated abscess situated beneath the interlobar pleural surface was visualized either at operation or subsequently. The intense reaction of the pleura about a perforating lung abscess agglutinates the apposing pleural surfaces and serves to wall off the abscess and prevent its spread into the general pleural space unless the perforation occurs very suddenly. The pleural exudate may be so thick as to obscure an underlying pulmonary lesion, or so sharply circumscribed as to simulate a primary parenchymal neoplasm. When a bronchopleural communication is established by perforation, air as well as fluid will be contained within the interlobar space.

In this series there were 13 cases of putrid, and 3 cases of non-putrid abscess. The one patient in whom the abscess cavity could be demonstrated at operation had had foul sputum at one time.

Although the clinical features of the lesion under consideration are not truly distinctive, the early history of essentially unproductive cough combined with severe localized thoracic pain is not usual in pneumonia. Expectoration of fetid sputum occurred during the course of the disease in most of the 16 cases. The physical signs were those of consolidation or fluid. The course of the disease is more severe and sustained than that usually encountered in postpneumonic empyema.

SUMMARY

Sixteen cases of interlobar empyema were studied. All were found to be due to a ruptured lung abscess. While the roentgenological evidence is not infallible, the following findings, present in more than half of the cases, were suggestive: (1) an interlobar collection of fluid, air, or both fluid and air; (2) a fluid level on or near a fissure; (3) an alteration of the shape of a fissure limiting an intrathoracic lesion, and (4) progression of disease along a fissure. There are no definite clinical criteria for the recognition of this lesion.

REFERENCES

1. Neuhof, H., and Copleman, B. Interlobar perforated abscess of the lung (interlobar empyema). *Surgery*, 1940, *7*, 236–253.
2. Rabin, C. B., and Neuhof, H. Topographic classification of primary cancer of the lung. *J. Thoracic Surg.*, 1934, *4*, 147–164.

PULMONARY MANIFESTATIONS OF AZOTEMIA*

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DURING the past few years, a number of cases of pulmonary congestion have been encountered which by their characteristic roentgen features were promptly recognized as pulmonary azotemic manifestations of cardiorenal disease. Associated with each of these were the blood chemistry findings of an elevated urea and creatinine content.

Review of the literature reveals a scarcity of specific references to pulmonary manifestations of azotemia. Roubier and Plauchu,[1] reporting 4 cases of pulmonary congestion similar to those under consideration, stated that they had never seen cases of this type without azotemia. Roesler[2] refers to this particular type of congestive lung failure and aptly describes it as an active, hypertensive, central pulmonary interstitial and intra-alveolar edematous transudation. Chapman[3] reported 2 cases of passive congestion of the lungs which possessed roentgen findings not unlike those of this group but which the author attributed to coronary sclerosis; no reference was made to the blood chemistry of these patients. Illustrations in the article by Zdansky[4] suggest that 2 of his cases probably were similar to this group. Both of these patients were said to have nephrosclerosis but no specific statement was made concerning blood study. Werkenthin,[5] in her discussion of lung edema, presents one case of congestion in a patient with nephrosclerosis, hypertension and uremia similar to those we have encountered.

As a whole, there has been a dearth of literature on the subject and because of the number of cases to be presented with characteristic roentgen and blood chemistry features, it has been deemed advisable to call attention to this roentgenographic complex.

Probably the main reason why this type of pulmonary congestion has not been more extensively recognized results from its rather infrequent occurrence as compared with other types of pulmonary edema. One other important factor which has proved quite perplexing is that it occurs in only a small percentage of patients having nitrogenous retention.

Clinically, these cases may not be recognized for pulmonary edema may occur in acute, subacute or chronic form. One must bear in mind that edema even of moderate degree may be latent and not produce the typical clinical picture of dyspnea, cyanosis or abundant foamy sputum. Those acute cases which are in a serious condition usually offer no diagnostic difficulty; whereas others with the latent form of lung edema are usually first recognized by means of the roentgenogram. This latter group occurs more frequently with disease of the kidneys associated with hypertension. Non-renal azotemic patients do not present such roentgenographic findings. The impression gained from the roentgen study is that it is most probably related to left ventricular failure. These individuals have some dyspnea, an increase in the systolic pressure and, unless there is aortic regurgitation present, there is also an increase in the diastolic pressure.

The roentgen appearance of an azotemic lung is that of a symmetrical, diffusely increased and irregular density located in the central and basal lung fields. The density decreases gradually as it extends to the lung periphery. The sites of predilection are the actively arteriolized portions of the lung. The increased density is caused by an intra-alveolar edema throughout the affected areas; in addition, there is the increased density of the pulmonic markings indicative of dilated vessels and associated interstitial type of congestion. Either of these processes may predominate. If the former element predominates, the affected areas

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may assume a nodular appearance, in which case a neoplastic (metastatic type) or inflammatory (pneumonic type) process may be simulated. If the latter feature is more pronounced, the roentgen findings are those which are commonly encountered in simple cardiac decompensation with resultant generalized hypervascularization of the lung fields. The accentuated markings usually extend uniformly to the peripheral and basal lung fields. In lungs manifesting azotemic pathology, the lung fields including the upper lobe apices and the lower lateral portions of the lower lobes remain relatively uninvolved and consequently are usually well illuminated. Radiolucent bands of the larger bronchi with contained air may at times be demonstrated within this amorphous non-homogeneous process. The cardiac surface may or may not be increased, but its borders may be difficult to distinguish because of absence of contrasting well aerated lung.

When there is a sudden failure of the left ventricle, a state in the lung develops which is recognized clinically as acute pulmonary edema. The inadequacy of the left ventricle causes a retrograde pressure phenomenon into the left auricle, right ventricle and pulmonary vessels. The bronchial arteries also become engorged as a result of the inability of the left ventricle to exert a sufficient force to fully empty them. As this sequence of events transpires, there ensues a dilatation of the pulmonary vessels with subsequent stasis causing the prominence of the mediastinal and hilar shadows. A marked degree of congestion follows, at which point the process is not unlike that seen in lung stasis due to chronic cardiac decompensation. In acute left ventricular failure, however, there occurs a marked transudation into the alveolar spaces and interstices of the lung structure, particularly in the mesial lung fields, producing pathologically lung edema. The explanation of this phenomenon has not been satisfactorily elucidated. Although many theories have been postulated, none are individually sufficient to explain the process fully.

Norris and Landis[6] and Osler and McCrae[7] believe that, due to a degenerative change in the vessel walls, there results an increased permeability allowing the fluid to pass into the tissue spaces and alveoli, the mechanical factor of increased pressure being concomitantly active in the production of transudation. The exact rôle of the vasomotor apparatus of the vascular structure of the lung is not fully understood but it is thought that a toxic factor may also affect and upset this control in such a manner as to be an important and vital agent in the production of pulmonary edema.

From the roentgenographic viewpoint it seems that the pulmonary changes associated with the azotemic state are simply an exaggeration of those occurring in acute pulmonary edema without a nephritic background. That the nitrogenous retention plays an important etiologic rôle in the production of the characteristic features is most probable. However, the fact that many cases with high blood nitrogen fail to present these changes would indicate that other factors must exert their influence. A thought of worthwhile consideration is that the toxic substance acting on the endothelial lining of vascular structures, which is assumed to be a factor in the production of edema in nephritic conditions, may also be an etiologic agent in the causation of pulmonary edema of azotemia. That this effect could be obtained not only through the direct action of the vessels, but also by disturbance of the vasomotor control is not unlikely. If the theory that the changes in tissue chemistry is a factor in nephritic edema, then it must be assumed that it also makes itself manifest in these cases. The most likely probability is that all these factors are mutually active and only when they are all present and exerting sufficient influence is the condition of pulmonary azotemia produced.

REPORT OF CASES

Case 1. J. E., aged fifty-six, white male, married, tailor, admitted February 20, 1939; discharged March 16, 1939. Complained of dyspnea

of two weeks' duration. Past history revealed patient had a fulguration of a bladder papilloma in June, 1918. Positive findings revealed an enlarged heart with accentuation of the aortic second sound. Moist râles throughout both lungs. Liver enlarged five finger-breadths below the costal margin. There was 2 plus pitting edema of the lower extremity. Blood pressure 136/96; temperature 100.8° F.; pulse 124; respirations 24. Clinical impression was that of arteriosclerotic heart disease, Grade 2B. Laboratory data: Electrocardiogram on February 21, 1939, showed sinus tachycardia, premature beats and coronary sclerosis. Blood chemistry: on February 21, urea 356, creatinine 4.1; on February 23 the blood urea was 45.8; creatinine 1.4. Wassermann reaction was negative. Patient responded well to digitalis and bed rest. Discharged in good condition.

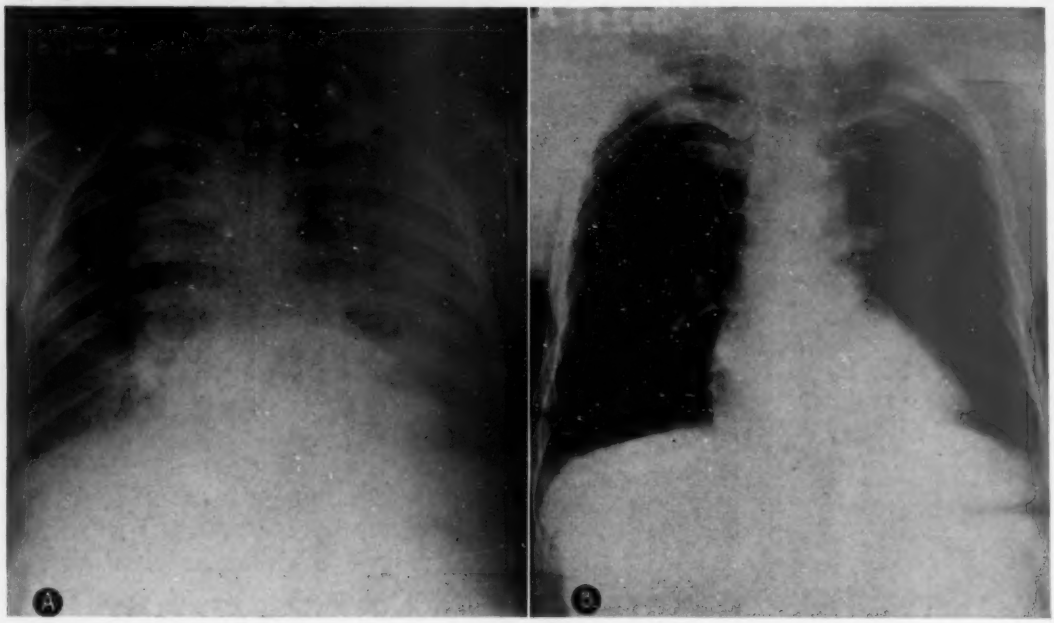

FIG. 1. Case 1. *A*, roentgenogram of chest on the day following admission. Patient was a male, aged fifty-six; two weeks' history of dyspnea. *B*, roentgenogram of chest two weeks later. Note complete disappearance of the azotemic manifestation.

CASE II. N. A., aged twenty-three, white male, single, typist, was admitted December 26, 1939; discharged January 16, 1940, Complained of swelling of the legs and vomiting of three weeks' duration. Patient had similar attacks off and on for the past five years. He was told he had a cardiac condition and was on a maintenance dose of digitalis. Physical examination revealed a well developed and well nourished white male, moderately dyspneic with edema of the extremities and face. The lungs were filled with moist râles. The heart was enlarged to the seventh intercostal space. There was a booming systolic murmur with reduplication of the second sound and gallop rhythm. The aortic second sound was accentuated. Blood pressure was 230/130; pulse 88. The liver was enlarged and tender. Clinical impression—glomerulonephritis, uremia, hypertensive heart disease. Laboratory data: electrocardiogram on December 28, 1939, showed sinus tachycardia and myocardial damage. Wassermann reaction was negative. Temperature 99° F. with occasional rise to 101° F. Numerous blood chemistry studies were done.

Date	Urea	Creatinine	CO_2 Combining Power
12/27/39	247	3.8	29%
12/28/39	237	5.0	
12/30/39	266	6.0	22%
1/ 2/40	292	7.5	28.1%
1/ 5/40	321	7.5	
1/ 8/40	401	8.6	
1/11/40	320	7.5	

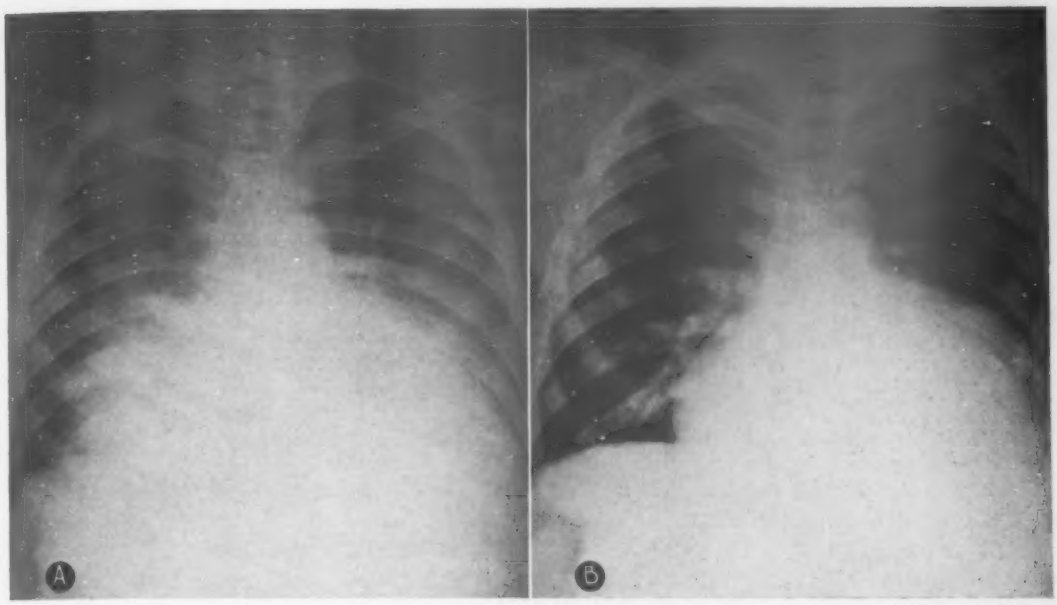

Fig. 2. Case II. *A*, roentgenogram of chest taken December 27, 1939. Patient complained of swelling of the legs and vomiting of three weeks' duration. Blood pressure 230/130. Blood urea varied from 247 to 401; blood creatinine from 3.8 to 8.6. *B*, roentgenogram of same patient after an interval. This patient died at home.

Urine showed many white blood cells, red blood cells and casts.

Patient's condition remained unchanged and he died at home following removal from hospital.

Case III. A. M., aged forty-one, white male, married, butcher; admitted December 20, 1937; died January 7, 1938. Patient had a chill three days previous to admission and a nonproductive cough. Later developed shortness of breath and blood-streaked sputum. A known hypertensive for four or five years. Nine weeks before had dyspnea, ankle edema and orthopnea. Examination revealed the following findings: Temperature 102° F.; pulse 120; blood pressure 230/140. The patient was acutely ill with cyanosis, orthopnea, and edema of the face and extremities. The eye grounds showed a hypertensive retinopathy. The neck veins were distended. There was marked enlargement of the heart and a systolic blow at the apex. There were bilateral basal râles. Clinical impression: hypertensive cardiovascular disease, chronic glomerulonephritis, bronchopneumonia. The patient was very toxic and became steadily worse. Laboratory data: Electrocardiogram revealed sinus tachycardia and coronary sclerosis. Urine was acid in reaction. Specific gravity, 1.013; 2 plus albumin; many casts, erythrocytes and leukocytes. Blood chemistry, February 29, 1937, urea 170; creatinine 1.8; March 3, 1937, urea 283, creatinine 5.

Case IV. M. F., aged fifty, white male, laborer; admitted November 14, 1939; discharged December 6, 1939. Patient was on a drinking bout for one week prior to admission. Following this he had vomiting spells with green vomitus. Physical examination revealed no abnormalities except malnutrition and poor oral hygiene. Temperature 99.2° F.; pulse 100; respirations 20; blood pressure 135/80. Clinical impression—alcoholic gastritis, avitaminosis. Laboratory data: Wassermann reaction negative. Blood chemistry on successive examinations—November 17, 1939, November 24, 1939, December 1, 1939, were urea 285, 102, 55. Creatinine ranged from 7 to 1.36. Urine showed a 2 plus albumin and few granular casts. There was a fixed specific gravity with the Fishberg test.

Case V. W. E., aged sixty-five, white male, machinist; admitted July 9, 1938; died August 27, 1938. Patient developed shortness of breath two weeks prior to admission. Orthopnea and

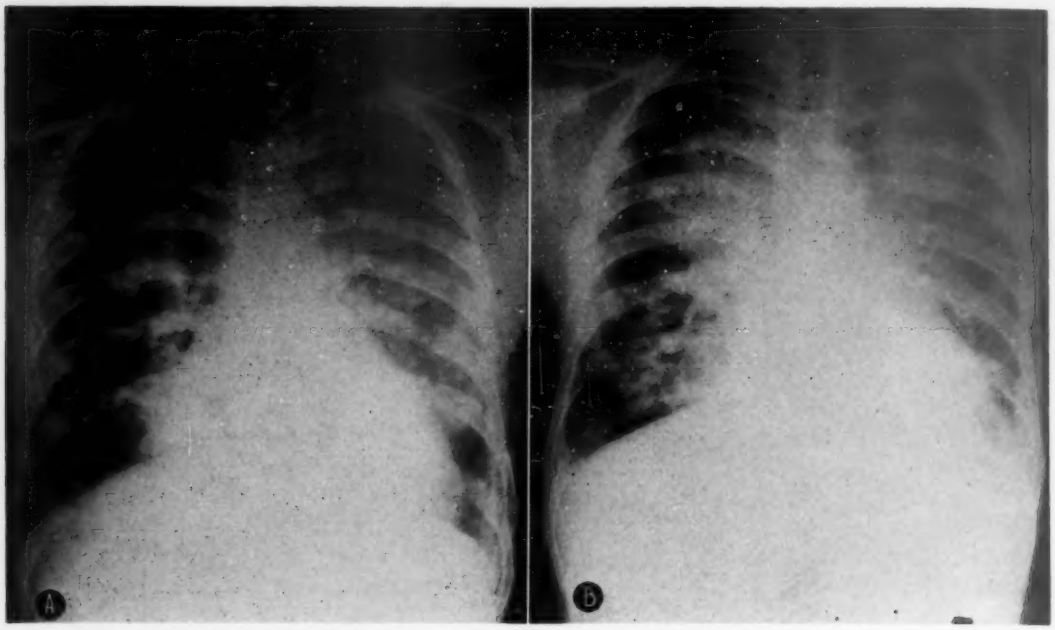

FIG. 3. Case III. *A*, roentgenogram of chest of patient, male, aged forty-one, a known hypertensive for the past four or five years. Blood pressure on admission 230/140. Blood urea 170; creatinine 1.8. *B*, roentgenogram of same patient a few days later.

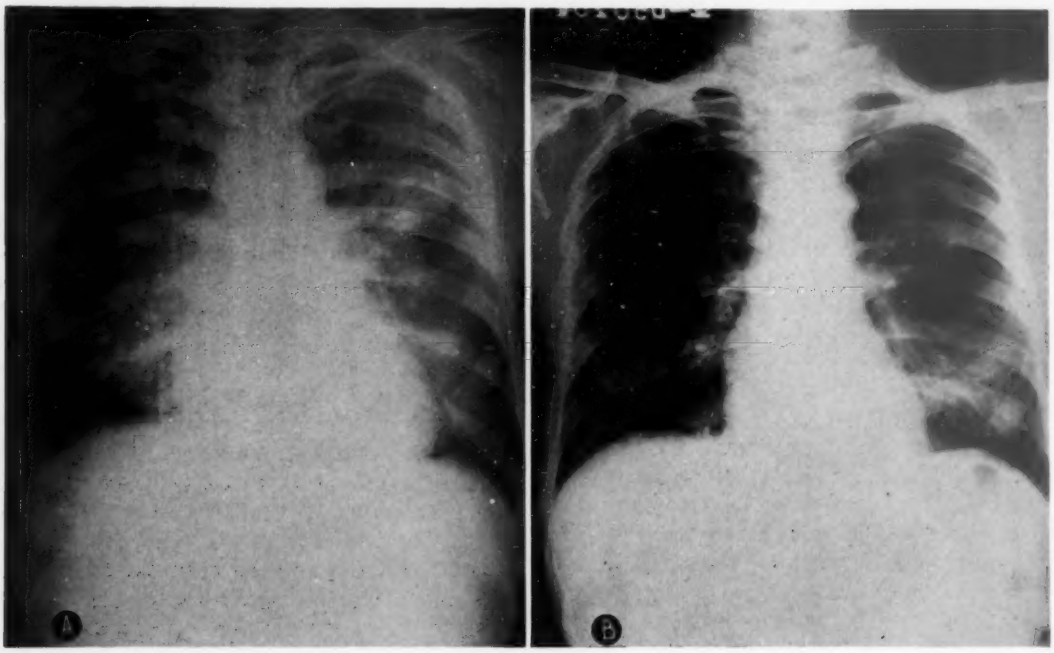

FIG. 4 Case IV. *A*, roentgenogram of chest of patient, male, aged fifty. Admitted after a severe drinking bout. The clinical impression was that of alcoholic gastritis and avitaminosis. Blood urea ranged from 285 to 55; creatinine from 6.0 to 1.36. *B*, roentgenogram of same patient after an interval of nine days. Discharged in good condition on December 6, 1939.

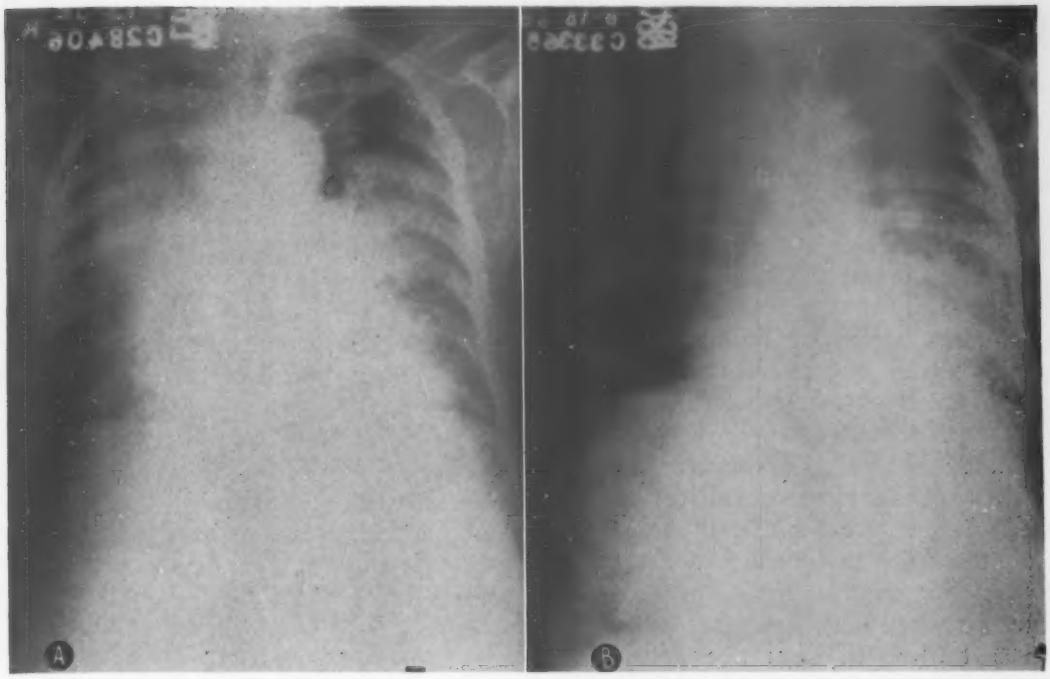

Fig. 5. Case v. *A*, roentgenogram of chest of patient, male, aged sixty-five, admitted with history of shortness of breath and ankle edema. Patient was a known hypertensive. Blood pressure 200/130. Blood urea varied between 90 and 55. His course was steadily downhill. Urine showed numerous casts and much albumin. *B*, same patient after an interval of approximately one month.

ankle edema for the past two days. Three months previously he was told he had high blood pressure. Physical examination revealed evidence of hypertensive cardiovascular disease with decompensation. Blood pressure 200/120. Clinical course was for the most part downhill, but there were days of apparent comfort and subjective improvement. Pulse was elevated out of proportion to the temperature. Patient had convulsions before death. Blood urea varied between 90 and 55. Wassermann reaction was negative. Urine 4 plus albumin, casts and cellular contents. Electrocardiogram showed left bundle-branch block and myocardial damage.

Case vi. L. G., aged fifty-one, white male, laborer; admitted February 8, 1939; died February 11, 1939. Patient was in good health until three months prior to admission when he complained of hoarseness and dysphagia. At the same time his nose began to run, the discharge containing blood. There were occasional headaches and vomiting after meals. Dyspnea and swelling of the face were also noted. Fifteen years ago he was told he had kidney trouble. Hematuria was present on occasions. Blood pressure 190/100; blood urea 475; urine showed

Fig. 6. Case vi. Roentgenogram of chest of patient, male, aged fifty-one. History of kidney trouble fifteen years ago. Blood pressure 190/100. Blood urea 475. Urine showed numerous casts. Patient died two days after admission.

4 plus albumin and casts. Patient died two days after admission.

DISCUSSION

An analysis of our cases from a clinical standpoint revealed several interesting facts. In endeavoring to find some correlation between nitrogenous retention and the roentgen pulmonary picture of azotemia, approximately 50 patients with elevated blood urea were roentgenographed and none presented any pulmonary manifestations of azotemia. It is in rare instances that the pulmonary features of azotemia are exhibited. When they do occur, one can be certain that there is some degree of nitrogen retention present. In several of the cases, the roentgenogram was the first to suggest that such a condition existed. It should be noted that the degree of elevation of blood nitrogen does not parallel the amount of lung changes. Marked pulmonary findings may occur with only slight elevation of blood urea (e.g., Case v). In all patients there were definite findings of renal damage. In Case IV there was a question of an extrarenal azotemic state but there were also positive findings indicating a kidney lesion. It seems that the presence of pulmonary changes is a poor prognostic sign and that if recovery is to occur there is a rapid clearing of the pulmonary infiltration with a simultaneous fall in the blood urea (e.g., Cases I and IV).

CONCLUSIONS

1. A positive diagnosis of pulmonary azotemia can be made from a roentgenogram of the chest.

2. The roentgen characteristics of pulmonary manifestations of azotemia have been presented. Its relationship to cardiorenal disease and nitrogenous retention has been proved constant.

3. The roentgenographic features are produced by stasis in the large pulmonary vessels with transudation and exudation into the interstices and alveolar spaces of the lung.

4. The peripheral portions of both pulmonary beds, the apices and lower lateral portions of the lower lobes are comparatively clear.

5. The costophrenic sulci are seldom obliterated.

6. If the roentgenographic azotemic complex remains constant, the prognosis is poor, for when recovery does occur, clearing of the lung fields is rapid.

REFERENCES

1. ROUBIER, C., and PLAUCHU, M. Sur certains aspects radiographiques de l'oedème pulmonaire chez les cardio-rénaux azotémiques. *Arch. méd.-chir. de l'app. respir.*, 1934, *9*, 189–200.
2. ROESLER, H. Clinical Roentgenology of the Cardiovascular System. Charles C Thomas, Springfield, Illinois, 1937, p. 119.
3. CHAPMAN, J. F. Passive congestion of the lungs in the presence of coronary sclerosis. *Radiology*, 1931, *17*, 342–345.
4. ZDANSKY, E. Beiträge zur Kenntnis der kardialen Lungenstauung auf Grund röntgenologischer, klinischer und anatomischer Untersuchungen. *Wien. Arch. f. inn. Med.*, 1920, *18*, 461.
5. WERKENTHIN, MARY. Roentgenological aspect of lung edema. AM. J. ROENTGENOL. & RAD. THERAPY, 1939, *41*, 183–187.
6. NORRIS and LANDIS. Diseases of the Chest. Third edition. W. B. Saunders Co., Philadelphia.
7. OSLER and MCCRAE. Diseases of the Circulatory System. Second edition. Vol. IV. Lea & Febiger, Philadelphia.

Vol. 46, No. 6

NEUROBLASTOMA AND ITS ROENTGEN DIAGNOSIS*†

REPORT OF EIGHT CASES

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NEUROBLASTOMA is a highly malignant tumor of the sympathetic nervous system derived from the undifferentiated parent cell, the neuroblast.

This tumor may occur wherever the neuroblast is present—most common in the suprarenal medulla, less frequent in the sympathetic ganglia and, curiously enough, it is extremely rare in the central nervous system where the neuroblasts are most numerous.

The neuroblasts of the sympathetics, like those of the central nervous system, arise from the neuro-epithelial canal and normally differentiate into sympathetic ganglion cells or into the chromaffin cells of the paraganglion. Tumors arising from these ganglion and chromaffin cells are mature, highly differentiated and comparatively benign. They are called ganglioneuroma and paraganglioma (chromaffinoma) respectively, and are not included in this paper.

According to Wiesel[34] the evolution of the suprarenal medulla may be prolonged even beyond puberty and it may contain undifferentiated formative neuroblasts in the second decade of life. Most likely, this is why the suprarenal medulla is the most common site of the neuroblastomas.

Besides the suprarenal medulla, neuroblastomas are on record as arising from the retina,[2] the sympathetic ganglia of the cervical,[19] lumbar,[31] and scapular[29] regions. Ewing's case[8] appeared in the left thigh of a child two years old, destroying all the muscles above the knee, invading the pelvis, kidney, suprarenal gland and finally metastasized to the lung. Ritter[24] has reported 3 cases which originated from Meissner's and Auerbach's plexus of the small intestine but he was able to find only 2 similar cases in the literature. Lewis and Geschickter[18] reported cases arising from the nose and forehead, retroperitoneal tissue, neck of the urinary bladder, thoracic cavity, coccygeal region and rib.

The distribution of the primary tumor in our 8 cases reported here was as follows: 1 occurred in the retina of the left eye; 1 was located in the spinal cord as an intramedullary cord tumor at the level of the fourth and sixth cervical vertebrae; 2 in the right, 2 in the left and 1 in both suprarenal glands. In 1 case which showed otherwise a textbook picture of the so-called Hutchison syndrome, the primary growth had not been located even at the autopsy. Both suprarenal glands were normal in size and appearance and the microscopic sections from either gland had shown no evidence of neoplasia. On the other hand, all microscopic slides from the metastatic lesions of the scalp, skull, ribs and long bones revealed a typical picture of neuroblastoma. The clinical course, roentgen and laboratory findings substantiated this diagnosis also.

The primary tumor is usually a well encapsulated, soft, nodular growth with considerable variation in size. Growths as small as 1 cm. in diameter are on record as well as bulky tumors which occupied two-thirds of a greatly distended abdomen that displaced the intestinal tract and ureters to the opposite side (see our Case VI, Figs. 4 and 6). Because the primary tumor tends to remain encapsulated, it does not usually invade the neighboring organs, with the exception of the liver which is often encroached upon through the extraperitoneal "bare area." The kidney is usually compressed but not invaded. The suprarenal

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cortex may be displaced by the tumor mass and if it is destroyed, the well known symptoms of adrenal dysfunction complicate the clinical picture. Smith[27] reported such a case which showed evidence of hirsutism including a very marked overgrowth of the eyelashes; however, we have not observed this phenomenon in any of our cases.

On a cross section of the primary growth, areas of hemorrhage and necrosis are common which darken the original yellowish-gray color of the tumor.

Microscopically, this tumor is very cellular and composed of small hyperchromatic round cells with very little cytoplasm which tend to form clusters. According to Lewis and Geschickter,[18] the cells are grouped together like the clumping of staphylococci. Wright[35] first described the presence of delicate fibrils which tend to form longitudinal bundles and sometimes round masses which are surrounded by groups of neuroblasts forming the so-called rosettes. This rosette formation has been found in one-third to one-half of the cases reported. In our series, rosette formation was found in 4 of the 8 cases, representing 50 per cent.

Because the neuroblastoma has close resemblance to a round cell sarcoma, it is very likely that many cases have been overlooked in the past. According to Ewing,[8] "it is necessary to include in this group many, if not most of the retroperitoneal round cell sarcomas of infants and many embryonal and peculiar growths of the cervical, thoracic and peripheral nervous system."

Sometimes, neuroblastomas are accompanied by ganglioneuroma or paraganglioma or both as reported by Dunn,[7] Herxheimer,[10] Wahl,[30] and Wahl and Craig.[31]

Though Caucasians constitute the majority in the case reports, a few cases in Negroes are on record. We have also had a Mexican boy, six years of age, under observation with neuroblastoma of both suprarenal glands and widespread metastases.

Neuroblastoma is more common in the male, as shown in 161 cases collected from the literature—92 in males and 69 in females.

Though neuroblastoma is primarily a disease of young children, there are cases on record which occurred in adults. Meltzer[20] reported 2 cases which occurred in adult males, and Symmers[29] observed one. Weichselbaum's[32] patient is probably the oldest case known—a white male, aged seventy-six, who had neuroblastoma of the left suprarenal gland with metastasis. The age distribution of 141 cases collected from the literature was as follows: congenital, 6; under five years of age, 99; from five to ten years, 16; from ten to twenty years, 8; above twenty, 12. Seven of our 8 patients were between three and seven years of age and the eighth fifty-six years of age when first seen.

Neuroblastoma is still considered a rarity. Redman and his coworkers[23] found only 275 cases of suprarenal origin recorded between 1880 and 1938. Kato and Wachter[13] analyzed the case reports more critically and found only 179 cases in the same period. However, Redman and his coworkers admitted that their estimation is "essentially an approximation." Tumors arising from organs other than the suprarenal glands are even more rare—only 7 of Lewis and Geschickter's 40 cases occurred elsewhere than in the suprarenal medulla or its adjacent sympathetic ganglion. Five of our 8 cases originated in the suprarenal gland.

Retinal origin of this tumor occurs almost exclusively in infants and young children, and according to Boyd[1] its familial tendency is striking. There is a family on record where 10 out of 16 children died of this disease. Our only patient having neuroblastoma of the retina was a white male, aged fifty-six, whose family history was not significant.

Since the time of Pepper's[21] and Hutchison's[12] often quoted papers, the neuroblastomas of the suprarenal gland have been classified into two clinical types: (1) the Pepper or abdominal and (2) the Hutchison or metastasizing types. But those writers who have had more than two or three cases under observation feel that there exists a

third, an "irregular" or "over-lapping" type, indicating that the above classification is arbitrary.

The classical Pepper type occurs in young children, usually under two years of age. It is of short duration, terminates fatally within a few months and is usually associated with great distention of the abdomen. The abdominal distention is due partly to the primary growth but mainly to a huge liver because most of the liver tissue is replaced by rapidly growing malignant cells. Ascites, as a rule, does not complicate the disease. The tumor and its metastases, as well as the symptoms, are confined to the abdomen. Nausea and vomiting may occur due to pressure of the tumor on abdominal organs. One of our patients had vomiting spells and nausea for five months prior to admission.

The Hutchison type occurs after two years of age and is usually recognized by its metastases occurring first in the scalp, skull, orbit, and later in the long bones. The primary lesion is palpable in 40 to 50 per cent of the cases and very often it was discovered at autopsy only. Increased intracranial pressure is common, sometimes resulting in wide separation of the sutures and the coronoid suture is involved most frequently. Orbital symptoms are present in a high percentage of the Hutchison type of neuroblastomas. Its most striking phenomenon is the proptosis of one or both eyes, due to both intraorbital metastasis and the increased intracranial pressure. This starts with swelling and ecchymosis of the eyelid and may reach such extremes that the entire globe is luxated from its socket (Fig. 1, *B*). The cornea is ulcerated because the eyelids cannot cover and protect it. Motion of the eyeball, vision and the pupillary reflex may be impaired but not necessarily.

Papillitis is present in all of the advanced cases, due to intracranial pressure and compression of the optic nerve by metastatic growth in the orbit. Kuhn's[14] case revealed large intra- and periorbital growths with a tremendous chemosis of the conjunctiva and ulceration of the cornea. The globe was luxated before the interpalpebral fissure and bone destruction were found on the head and neck of the left mandible, orbital bones and the mastoid area. In Seefelder's case[26] the superior orbital fissures and both optic foramina were obliterated by tumor tissue and the optic nerves were imbedded in it. The lacrimal glands were enlarged in one of Leifelder's cases and it was surrounded by tumor tissue in Wessely's[33] case. Lagophthalmos was observed in a case of Coppez, Simon and Claes.[4] Lederer's[16] patient developed facial paralysis due to metastasis. Hill[11] diagnosed a case by orbital biopsy three months preceding a palpable abdominal mass.

Three of our 5 suprarenal cases have had orbital symptoms—2 of them exophthalmos and 1 developed internal strabismus during hospital observation. Curiously enough, the fourth orbital case where the site of the primary growth had not been located, even at autopsy, showed the most extreme ocular involvement. Both eyeballs were extremely protruded from their sockets due to intra-orbital metastatic tumor masses.

The abdominal symptoms in the Pepper type, the cranial, orbital and other symptoms, due to widespread metastasis in the Hutchison type, are preceded by pallor, wasting and listlessness of a few months' duration—longer in the Hutchison type. An irregular temperature elevation is common. Painful, sometimes swollen joints may simulate a rheumatic fever. One of our patients had intermittent rheumatic fever-like symptoms fourteen months prior to admission and after removal of tonsils temporary relief was obtained. Tenderness of the metaphyseal portion of the long bones is due to bone metastasis. Numerous subcutaneous nodules, evidently metastatic, were observed in a few cases as reported by Capon[3] and Smith.[27] They were not observed in our series.

Anemia is a constant symptom and may be very severe in advanced cases of the Hutchison type, due to invasion of the bone

marrow by malignant cells. The red blood cells varied between 980,000 and 3,860,000 with an average of 1,876,000 in our 5 suprarenal cases also in the case where the site of the primary tumor was uncertain. The hemoglobin was too low to read in one of the above cases; it varied between 20 and 43 per cent (Sahli) in the remaining with an average of 27 per cent. It is interesting to note that both the red blood cell count and the hemoglobin estimation were close to normal in Cases VII and VIII where the primary growth occurred in the spinal column and retina respectively. Case VII had 4,470,000 red blood cells with 80 per cent hemoglobin; Case VIII had 4,150,000 red blood cells with 80 per cent hemoglobin. Bence-Jones protein test was done in Case IV only, and was repeatedly negative. Cerebrospinal fluid examination in Cases II and VII revealed albumin 4 plus in both cases; 780 red blood cells and 3 white blood cells were found in Case II; no red blood cells but 2 lymphocytes were reported in Case VII. There was no evidence of spinal block by the Queckenstedt test in either case. Urinalysis and blood Wassermann reaction were negative in all 8 cases.

It is definitely known since Wright's[35] histological study, that the Pepper and Hutchison syndromes are just different manifestations of the same malignant disease. While the Pepper type is characterized by abdominal symptoms of the primary growth and its neighboring metastases—the Hutchison type is manifest by distant metastases, namely cranial, orbital and skeletal. Many observers of this disease were puzzled by this divergence in the route and appearance of the metastasis of an otherwise identical tumor and tried to find an explanation of it.

Frew[9] in his dissertation stated that the Pepper syndrome is due to neuroblastoma of the right suprarenal gland and Hutchison's to involvement of the left suprarenal gland. He believed the variation in metastasis of the right and left suprarenal tumors is due to the different anatomical lymphatic arrangement of the two glands. He demonstrated by dissections that the lymphatics of the right suprarenal gland run into the right lymphatic trunk with practically no anastomosis to the lumbar lymph nodes, but the lymphatics of the left adrenal anastomose extensively to the lumbar lymph nodes. His theory explains the widespread metastases to the skull and skeleton (Hutchison syndrome) in left-sided cases and the abdominal confinement (Pepper syndrome) of the right-sided cases.

It is interesting to note that his paper was misinterpreted many times, some believing his theory to be that the route of metastasis in right-sided cases is through the lymphatics and in left-sided cases through the blood stream.

Though he was right in that metastasis of the suprarenal neuroblastoma travels via the lymphatics and his anatomical basis was sound, nevertheless his theory has not been proved to be correct. Even a superficial review of the literature discloses that in the suprarenal neuroblastomas, the site of the primary tumor has but little importance in the evolution of the clinical syndrome. Among 56 Pepper type neuroblastomas collected from the literature, the primary growth originated from the right suprarenal gland in 27 cases only, from the left in 21 cases and from both glands in 8 cases. A similar distribution of the primary tumor was seen in the Hutchison type. In 83 verified cases, 35 originated from the right suprarenal gland, 38 from the left and 10 revealed bilateral involvement.

It has long been accepted that the Pepper type runs a much shorter course than Hutchison's, indicating more rapid cellular proliferation. Also, it is possible that the duration of the Hutchison type is even longer than we have believed because the diagnosis is usually made from its metastases and not from the primary lesion. Most tumors of any kind have slowly and rapidly growing varieties and every oncologist has seen cases of late metastases occurring long after cure at the primary site. Evidently these late metastases were the result of cell transfer at a time when the

primary growth was in an active state and they remained dormant for a long period. Our Case VII, when first seen, was so similar to Pepper's original patient that his classical description could have been applied. There was a huge distended abdomen, due to the enlarged liver and a large primary tumor of the right suprarenal gland. The only exceptions were that our patient was six years of age, rather than twenty-eight days, and for six months had had symptoms. This patient evidently was a Pepper's type on admission, then changed to a Hutchison's type during hospitalization. He developed metastases to the scalp, cranial bones, right humerus and pelvic bones. Internal strabismus of the right eye developed, also followed by edema of the left eyelid.

These facts suggest that all neuroblastomas metastasize during an early stage of the primary growth. However, in the rapidly growing primary tumor (Pepper's type) the metastases are inactive simply because they lack the sufficient time required to reach an effective and recognizable extent, whereas they dominate the clinical picture in case of a slowly growing primary tumor (Hutchison's type). Evidently, the growth of the primary tumor was not sufficiently rapid to cause death in our Case VI, allowing the metastatic lesions time enough to become prominent in the clinical picture. This case, as well as all the so-called "irregular" or "overlapping" types mentioned often in the literature, is apparently a connecting link between the Pepper and Hutchison types and suggests that the distinguishing characteristic is the rate of growth of the primary tumor.

Due to the rarity of the cases, articles dealing with the roentgenological aspect of this disease are scarce; even the best American and European textbooks of roentgenology offer practically nothing on this subject. Because only a limited number of cases were observed by each author, the diagnostic clues found and conclusions drawn were not in agreement and certain signs were overemphasized.

The presence of fine rectangular bone spicules along the cranium and epiphyseal ends of the long bones were believed by a few authors to be a definite diagnostic sign. We believe similar changes may be present in the cranium in blood dyscrasias and in the long bones due to osteogenic sarcoma, Ewing's tumor and syphilis. We have had a case of Ewing's tumor of the fibula which showed numerous rectangular bone spicules and none of the well known longitudinal reduplication of the periosteum—the so-called onion peel sign. There are many specimens of bone syphilis in the museum of the Surgeon General, at Washington, D. C., which show rectangular periosteal bone spicules. We, too, had a similar case occurring in a luetic girl aged sixteen. In our Case II (Fig. 11) the roentgenogram of each femur showed these rectangular bone spicules and could easily be misdiagnosed as osteogenic sarcoma if seen separately. The literature also reveals a few cases which were diagnosed as osteogenic sarcoma and Ewing's tumor prior to biopsy or autopsy.

The periosteal elevation of the long bones, which we believe is one of the most characteristic roentgen signs, has been listed as a rare finding in neuroblastomas and has been said to be "more typical of leukemia or lymphosarcoma of bones."

Our experience is based on complete and repeated roentgenograms of the entire skeleton in 5 cases, the material available on this subject from the Registry on Bone Sarcoma and on a study of numerous case reports and illustrations of roentgenograms from the literature. Unfortunately, roentgenograms were not obtained in Case I because of death within twenty-four hours after admission to the hospital.

Though unusual roentgen appearance in this disease may occur, as well as in any other disease, we believe that the majority of the Hutchison type could be diagnosed from the roentgenograms alone.

We have found the following roentgen signs to be characteristic: widening of the cranial sutures, apparently due to increased intracranial pressure, was present in 3

cases; all sutures were involved in Case II and only the coronoid suture was separated but to a greater degree in Cases III and V. Minute bone spicules extending from the considerably decalcified outer table into single or multiple soft tissue masses were present in 2 cases (III and V) only. It is interesting to note that no bone spicules, even the smallest, were found without a soft tissue tumor and in our series, all were associated with widening of the coronoid suture. No bone spicules were seen in the cranial bones of Case II, in which all sutures were separated, though several soft tissue tumors were present (Fig. 2, *A*). In addition to these, there were innumerable small areas of diminished density due to bone destruction which principally involved the parietal bones. This produced a so-called mottled appearance with areas varying in size from pinpoint to a few millimeters and in some places forming small irregular confluent patches. The roentgenogram of the skull in Cases IV and VI was entirely different. There were numerous, rather large areas of destruction similar to those produced by metastatic carcinoma or sarcoma. Curiously enough, the sutures were intact in these 2 cases. The sella turcica was involved in 2 cases only. In Case V, its floor showed some roughening and the whole sella was destroyed in Case VI.

The long bones revealed the most characteristic roentgen diagnostic signs. All long bones involved, in our series, showed a definite periosteal thickening in a quite irregular manner. One or both epiphyseal ends in certain bones were involved; the midshafts in others, and in a few cases it was present along the entire bone. The periosteal involvement was very unusual on the lateral surface of the left femur in Case III; it was two-thirds as wide at the midshaft as the bone proper and had the appearance somewhat of the subperiosteal hemorrhage of scurvy. Rectangular bone spicules, the so-called whiskers, were present in only one case of our series. They occurred at the lower end of each femora in Case II and were associated with the characteristic longitudinal periosteal thickening (Fig. 11).

Another significant roentgen finding was the multiple bone destruction which was more frequent at the epiphyseal ends of the diaphysis but, in a few cases, they were limited to the midshaft (Fig. 9, *B*). They varied in size from minute foci of diminished density to confluent areas of bone destruction of several square centimeters. It was so extensive in Case IV that a pathological fracture resulted at the transtrochanteric line of the right femur (Fig. 8). It is interesting that the extent of the periosteal thickening and bone destruction was not in proportion at all. There was only moderate bone rarefaction of the left femur in Case III where the periosteal thickening was the most extensive in our series (Fig. 9, *B*), and the periosteal thickening was absent in the upper femoral region in Case IV, where a pathological fracture occurred, due to extensive bone destruction.

Though no metastatic lesion with bone proliferation in the flat bones was present in our series, such a form of metastasis may occur as shown in Figure 12. This is the roentgenogram of a case on record with the Committee on Bone Sarcoma—Registry No. 1705—sent to us at our request. This is the right iliac bone of a girl, aged twelve, who developed a large hard mass in the right iliac region. The roentgenogram revealed a tumor mass with considerable new bone formation, apparently attached to the iliac crest. Microscopic study from biopsy material showed a typical picture of neuroblastoma. Later, another metastatic growth occurred on the forehead. The primary growth was detected as a "slight resistance" over the right kidney region about eleven or twelve months after the appearance of the metastatic growth of the iliac bone. A mild hirsutism was noted in this case in that the pubic hair was stated to be possibly more profuse than would be expected in a girl of her age, indicating involvement of the suprarenal cortex.

Fig. 1. *A*, Case III. Mild bilateral exophthalmos, metastatic tumors on forehead and anterior part of scalp. *B*, Case II. Extreme exophthalmos, both eyeballs are luxated forward and resting on cheeks.

From the differential diagnostic point of view, blood dyscrasias and, probably in certain cases, an early osteomyelitis should be considered. They can easily be eliminated by laboratory findings and careful history of the onset and clinical course.

No therapy of any kind can alter the fatal course of this disease. Most of the writers on this subject believe that surgery is harmful and irradiation not beneficial in these cases. Roentgen therapy was given in Cases IV and VI without any effect. One thousand roentgens, with 200 kv. technique, to each of four fields on the anterior abdominal wall in Case VI could not even stop the rate of the metastatic growth. Curiously enough, the cranial and skeletal metastases appeared during roentgen treatment in this case and we had difficulty convincing the parents that the irradiation did not "spread the cancer." There is only one exception among these fatal cases—Lehman's[17] patient who was reported alive and well fifteen years after operation.

CASE REPORTS

Case I (Hospital No. 93220). B. E., white male, aged four, was admitted to the hospital on August 20, 1937, with abdominal swelling, anemia and weakness. The mother noticed the boy getting pale two or three months before admission. He complained of pain in his side usually after eating. However he played and got along fairly well until four weeks previously when he had poliomyelitis. While in quarantine, the mother noticed his abdomen was enlarging very rapidly A month before this he had black spots under his eyes. No bleeding was noted externally and he complained of pain in left costovertebral angle.

Physical Examination. A pale, emaciated, subacutely ill boy four years of age. Head and neck normal except for pallor, chest clear and heart normal. Abdomen was distended with a large firm nodular mass in left kidney region, nodular enlarged liver, multiple firm masses over abdomen and paralysis of lower extremities. There was no marked tenderness.

Laboratory Findings. Hemoglobin too low to read; red blood cells, 980,000; white blood cells, 8,900 with normal differential.

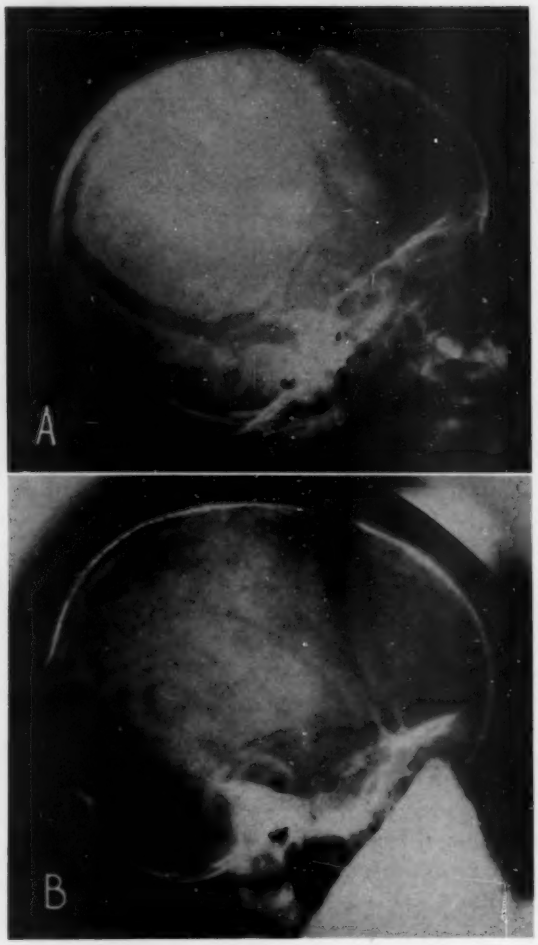

FIG. 2. *A*, Case II. All sutures are separated, metastatic growth on right upper parietal region; *B*, Case III. Coronoid suture is separated, metastatic growth on upper frontal region.

Due to severe anemia, it was deemed necessary to give the patient a transfusion the next day after admission. On the second day 350 cc. of blood was given together with 200 cc. 10 per cent of glucose. This took sixty-five minutes. At the end of that time he became acutely short of breath, cyanotic, suddenly stopped breathing and heart stopped beating. An autopsy was secured and permission given to biopsy the tumor mass. This revealed a large nodular hard tumor which seemed to arise from the left kidney—the right kidney was normal. Gross anatomical diagnosis: tumor of the left kidney (hypernephroma).

Microscopic Examination. Sections from different areas consisted entirely of tumor, fibrin and blood. The tumor cells were very poorly differentiated, somewhat loosely arranged. Nuclear material predominated for the most part; cells small, round, or oval shaped and nuclei dark staining. Cells resembled medullary neuro-epithelium and a few fibrils. In some areas there was a tendency toward rosette formation and a tremendous amount of extravasated blood and fibrin with tumor infiltrating. Microscopic diagnosis: neurocytoma.

No roentgen examination was made as the patient died on second day of admission.

CASE II (Hospital No. 77972). R. H., white male, aged five, was admitted to the hospital December 5, 1924. Six weeks previous to child's admission the size of his head had increased rapidly, the eyes were swollen and the skin around them dark. However, three weeks be-

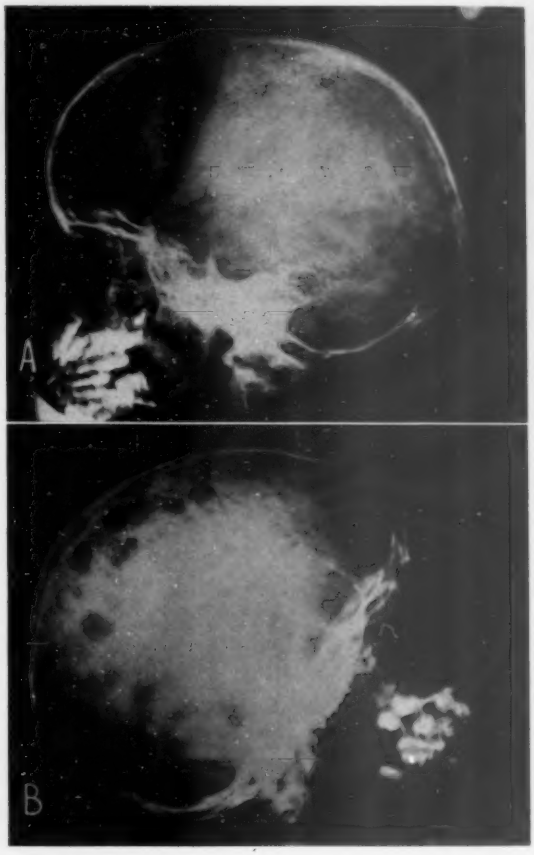

FIG. 3. *A*, Case V. Separation and marked widening of coronoid suture. Rectangular bone spicules at mid upper parietal region surrounded with many small areas of bone destruction. *B*, Case IV. Round areas of bone metastases are scattered over frontal and parietal bones, sutures are normal.

fore admission, the eyes protruded from their sockets. Past medical and family history irrelevant.

Physical Examination. A boy, five years of age, whose head was twice the normal size, with eyes protruding 1 inch from his head, cornea and sclera degenerated and eyeballs infected. His mental condition was good and apparently

Patient did not improve; he started labored breathing on December 27, and died within a few hours. Autopsy was done.

Gross Anatomy. Ribs and one femur showed subperiosteal hemorrhages with beginning organization. There were also a few pink ovoid nodules about 15×8 mm. beneath the sternal costal cartilage which appeared as lymph nodes.

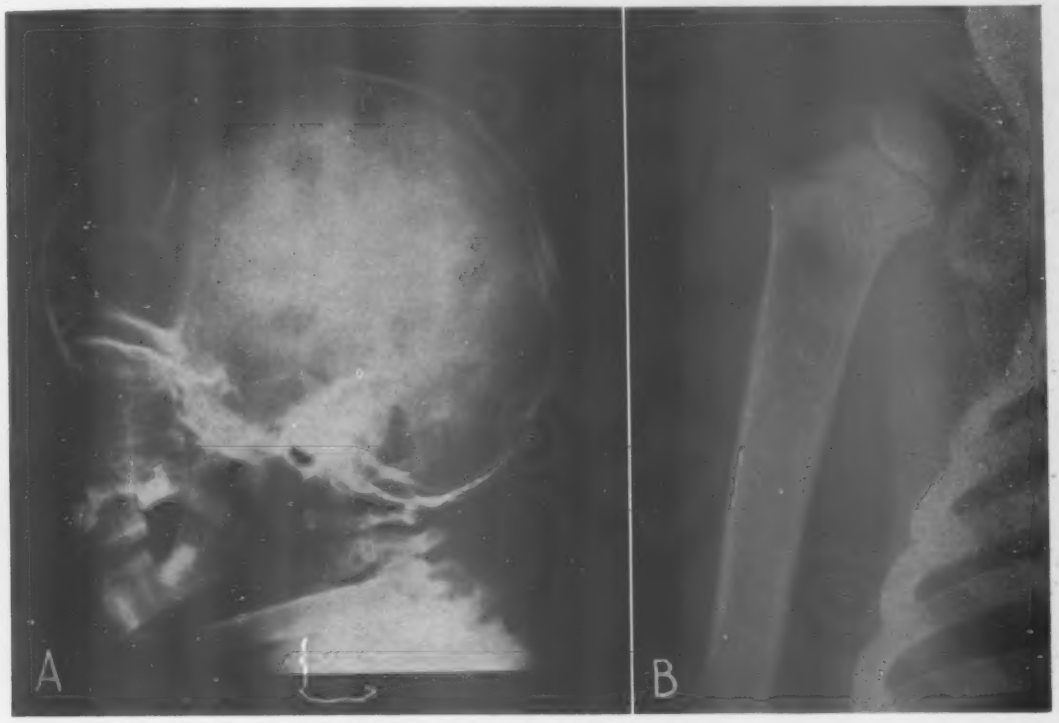

Fig. 4. Case vi. *A*, three round areas of bone destruction on upper parietal region. *B*, many minute foci of bone absorption at the surgical neck, fine periosteal elevation along lateral surface (roentgenogram taken a week before this one was negative).

there was but little pain. Subgaleal or subpericranial masses over the scalp proved to be a collection of thin blood. The remainder of the physical examination was not remarkable.

Laboratory Findings. Hemoglobin 30 per cent (Sahli); red blood cells 1,380,000, with marked anisocytosis, poikilocytosis and polychromasia; white blood cells 9,800, normal differential; Wassermann reaction negative; calcium 10.8 mg. per 100 cc.; phosphorus 4.6 mg. per 100 cc.; cholesterol 190 mg. per 100 cc. Urinalysis was negative and no malarial parasites were found. Cerebrospinal fluid: red blood cells, 780 with 95 per cent crenated; white blood cells, 3 (2 neutrophiles, 1 lymphocyte); globulin, 4 plus. No indication of block.

Thoracic and abdominal viscera grossly unimportant and ilia had a bulging mass of soft periosteal blood clot bilateral. The scalp revealed subperiosteal hemorrhages or organized blood; both orbital cavities were filled with similar material. The bones of the face, in region of orbits, appeared somewhat honeycombed. The blood clots penetrated the bone in irregular small areas. In one area over the vertex, a small ovoid mass protruded inward from the dura to depress the brain tissue. Brain weight was 1,050 grams; surfaces smooth and regular, vessels normal, ventricles normal in size, and section revealed evidence of hemorrhage, tumor or abscess.

Microscopic Examination. All hemorrhagic

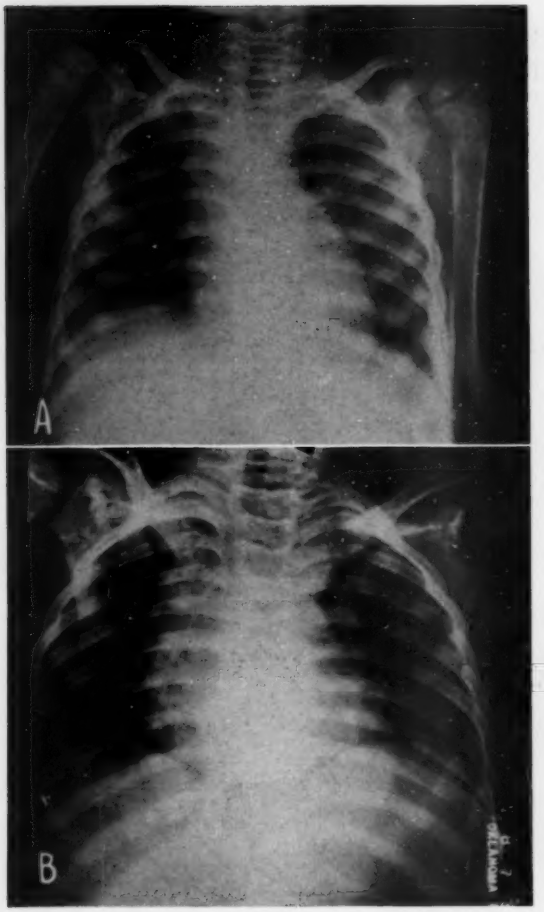

FIG. 5. Case II. *A*, metastasis in right upper mediastinum. Mottling of surgical necks of both humeri, fine periosteal elevation at lower part of bone lesions. *B*, areas of bone destruction involving prac tically all bones of thorax.

areas and tumefactions described in the gross, showed a similar microscopic picture as follows: A very cellular tumor with a variable amount of stroma. This stroma was moderately abundant but not dense; the blood spaces occupied a considerable portion of the tumor everywhere. Tumor cells tended to form irregular, small groups of infiltrating strands—taking for the most part a dark stain, having very little cytoplasm and ranging from ovoid to spheroid. Some of the sections from the regions of the bone showed necrotic bone trabeculae. An occasional small area showed cells in clusters or roughly in rosettes. Adrenals were apparently normal and definite evidence of neoplasia could not be demonstrated. Heart, spleen, lungs, pancreas, colon and liver unimportant. Microscopic diagnosis: neuroblastoma, exact origin of the tumor is uncertain.

CASE III (Hospital No. 89843). I. K., white female, aged four, was admitted to the hospital December 26, 1936, complaining of pain in the left leg and swelling in the right arm. The parents noticed that the girl walked with a limp of the left leg fourteen months previously, and complained of a pain in the leg. On manipulation this would become severe. Symptoms disappeared entirely within three or four days but returned three months later. Diagnosed as rheumatism. Tonsils and adenoids removed in April, 1936; no symptoms for the following two months. Three months previous to admission, pain was continuous and patient had difficulty in walking because of weakness in the left leg. In addition, a painful, non-inflammatory swelling appeared in the right arm.

Physical Examination. A fairly well devel-

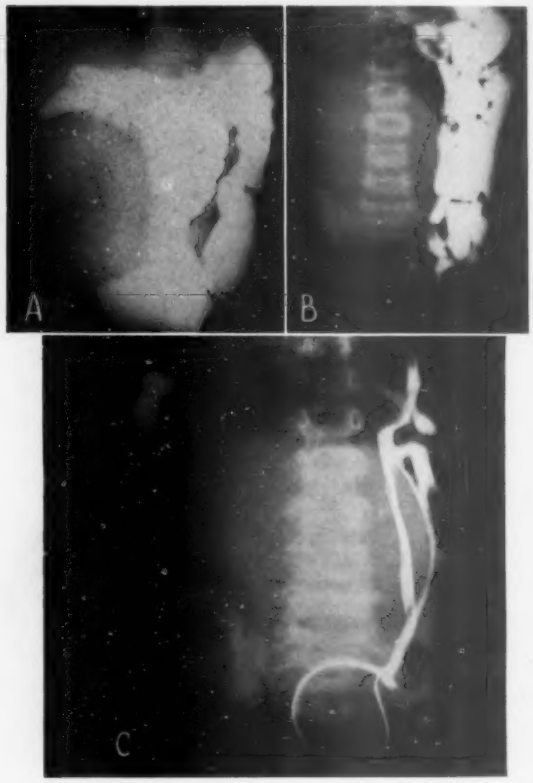

FIG. 6. Case VI. *A*, barium enema: ascending and sigmoid colon displaced to left. *B*, stomach and (arrow) duodenum, also all small intestines displaced to the left. *C*, right calyces and kidney—pelvis flattened, right ureter (arrow) displaced to the left and lying lateral to left ureter.

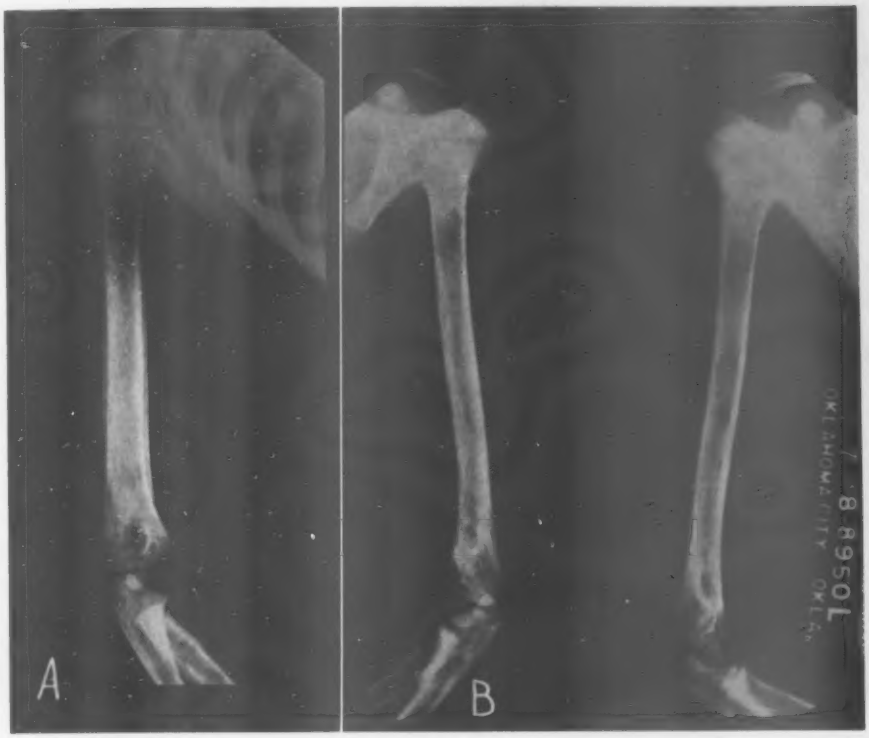

Fig. 7. *A*, Case III. Periosteal elevation along the shaft of humerus. *B*, Case V. Bone destruction and some periosteal elevation involving both humeri.

oped white female, four years of age, appeared anemic and quite irritable. She had a few nodules on the scalp that were soft, rather tense and the size of a hickory nut. The eyeballs were prominent, suggesting exophthalmos, and the conjunctivae were pale. There were a few coarse râles but the resonance was unimpaired. Heart showed diffuse precordial impulse, no thrill or murmur was audible. Abdomen was soft, spleen four fingerbreadths below left costal margin and on manipulation the knees and elbows showed marked tenderness. Tibiae showed periosteal thickening with tenderness about metaphyseal ends of both radius, ulna, humerus and tibia.

Laboratory Findings. Urinalysis negative; hemoglobin 15 per cent (Sahli); red blood cells 1,190,000; normal red cell smear; white blood cells 8,900 with neutrophiles 66 per cent; myelocytes 4 per cent; small lymphocytes 20 per cent; large lymphocytes 6 per cent; monocytes 4 per cent.

Microscopic Examination. Smears made from aspiration biopsy, stained with hematoxylin-eosin showed blood predominating and throughout appeared scattered colonies or islands of small moderately dark blue stained cells having a great variety of shapes and heterogeneous arrangement. Apparently there was no stroma or cytoplasmic material demonstrable. Microscopic diagnosis: neuroblastoma.

Roentgen examination of the entire skeleton was made (see Figs. 1*A*, 2*B*, 7*A*, and 9*B*) and roentgen therapy was decided upon. Several blood transfusions were given previous to radiation therapy. The admission temperature was 104° F., which varied from day to day, usually between 100 and 103° F., the highest being in the afternoon about four o'clock. Pulse ranged from 100 to 140. After the roentgen therapy, the temperature gradually subsided and during the last ten days of hospitalization it varied from 99 to 100° F. No further report was available.

Case IV (Hospital No. 69096). J. W., Mexican male, aged six, was admitted to the hospital July 1, 1933, complaining of pain in the right hip and leg for a period of five months, loss of appetite, nausea and occasional vomiting. The

pain was so severe that three months previous to admission he was unable to walk. His local doctor had put on a cast which had been on for forty days, but his condition had become steadily worse. Past medical and family history was irrelevant.

Physical Examination. A well developed and nourished Mexican boy, six years of age, was lying in bed with right knee partially flexed and complaining of pain in right thigh. He appeared somewhat anemic. Head was negative, tonsils hypertrophied, chest normal. The heart was normal in size, rate 120 with a normal rhythm, and a systolic murmur was heard at the apex. Abdomen showed no palpable masses, tenderness nor rigidity. The right lower extremity showed knee flexed with marked tenderness to slight pressure. No evidence of swelling from region of knee to hip. Left lower extremity was normal.

Laboratory Findings. Hemoglobin 43 per cent (Sahli); red blood cells 2,250,000; white blood cells 6,300; normal differential. Wassermann reaction negative; urine normal; blood calcium 10.2 mg. per 100 cc.; phosphorus 5.0 mg. per 100 cc. Repeated test for Bence-Jones protein negative and tuberculin negative.

On first admission the temperature remained at 100 to 103° F. Roentgen examinations revealed destruction of femur, having the appearance of osteomyelitis, and there was a pathological fracture of right hip. When informed of the prognosis, parents decided to take the child home.

Patient was admitted again on August 3, 1933, his condition having become worse since being at home. He had developed complete incontinence of urine, loss of some sensation of pain in lower extremities. Laboratory findings at this time: red blood cells 1,650,000; white blood cells 9,300 with normal differential; urine showed 1 plus albumin and 30 white blood cells per high power field. The patient's condition grew steadily worse, he ran a septic type of temperature and died September 9, 1933. Autopsy was obtained.

Gross Diagnosis. Multiple metastases of the skull, ribs, long bones, pelvic bones and spinal

FIG. 8. Case IV. Marked bone destruction of all bones of pelvis and both lower extremities. Note pathological fracture of right hip.

Fig. 9. *A*, Case IV. Marked bone destruction of adjacent bones of both knees. Note periosteal elevation of both femoral shafts. *B*, Case III. Periosteal elevation of both tibiae and femora with some bone destruction. Note unusually wide periosteal reaction of left femur.

column; stasis and pleurisy of lung; congestion and fatty degeneration of liver and otitis media, left.

Microscopic Examination. Adrenal glands showed tumor with an abundance of protoplasmic material. In some areas this had the arrangement and staining characteristics of fibrils; in others, the appearance of dense fibrous stroma. Scattered throughout were islands and an occasional strand of tumor cells which altogether had considerable variation in size, shape and staining characteristics. An occasional cell appeared to exhibit a typical fibril and in some cases, there was a tendency to rosette formation. Tumor cells within the adrenal gland were large and some multinucleated, while in the metastatic lesions and in some areas within the gland itself, the cells were small and round or ovoid. Microscopic diagnosis: neuroblastoma.

Sections of the tumor from the skull, ribs and vertebrae all similar. There was a delicate, diffuse, pale-staining stroma, many small blood spaces and the tumor cells although heterogeneously arranged, had a tendency to irregular grouping and in many areas appeared in rows. Cytoplasm for the most part was scanty in these areas and the nuclei tended to be small but showed considerable variation in size, shape and staining qualities. An occasional area had large vessels packed with blood. There were metastases in the pancreas and mesenteric lymph nodes. No evidence of tumor invasion in kidneys, lungs, heart, spleen or liver.

Case V (Hospital No. 97389). E. C., white female, aged five, admitted to the hospital July 1, 1938, complaining of loss of weight and strength for the past four months. She had been perfectly well until February, 1938, but in March had whooping cough, noticed weakness, loss of appetite and weight—also developed pains in one side and in both legs. About a month previous to admission, bumps appeared

FIG. 10. Case v. Periosteal elevation and bone destruction involving all long bones of both lower extremities. Note widened medullary canal at upper shaft of left femur.

on her head, one of which had been drained by local doctor and was still draining.

Physical Examination. A well developed white female, aged five, with marked cachexia, disinterested facies, muscular atrophy and weakness; temperature 101.6° F., pulse 160. The head had a large fluctuant mass in scalp, right frontoparietal region with a similar mass on the right parietal prominence. Discrete, firm, elastic, non-tender, mobile nodes palpable along suboccipital region, postauricular, posterior cervical, deep cervical and along anterior cervical chain. Eyes: exopthalmos and upper lids edematous. Ears, nose and throat essentially normal. Chest showed kyphosis on sitting, breath sounds normal with no râles. Heart: diffuse precordial impulses to anterior axillary line, enlarged both to right and left and no significant murmur. Celer type of pulse, rapid rate but regular. A large mass was found in right abdomen extending from right costal margin to below umbilicus and to left just beyond epigastrium; edge was hard and nodular in epigastrium, conforming to liver contour, pulsating with loud to and fro murmur over entire mass. Spleen and kidneys palpable; extremities and genitalia normal.

Laboratory Findings. Hemoglobin 20 per cent; red blood cells 1,590,000; white blood cells 9,200 with normal differential. Wassermann reaction and urinalysis negative. A provisional diagnosis was made of Wilms' tumor with metastases to skull—possible neuroblastoma type.

Patient was given a transfusion while in the hospital and a node from the posterior cervical region biopsied. This report showed tissue to consist almost entirely of very poorly differentiated, embryonal type of tumor. Most of the cells were very irregular with dark staining nuclei which almost completely occupied the entire region. There was no definite arrangement but a tendency to grow in sheets and masses and in some areas a small amount of stroma. In other areas, the cells were grouped

together in compact, dark staining masses resembling, in some respects, small lymphocytes. Cells that occurred in pockets were lighter staining and somewhat larger. Microscopic diagnosis: neurocytoma.

The patient improved somewhat while in the hospital and was discharged on the eighth day. A communication from the parents later stated that the patient died on August 2, 1938.

CASE VI (Hospital No. 105529). R. D. A., white male, aged three, was admitted to the hospital on April 9, 1940. His symptoms were pallor, weakness, and huge uniform distention of the abdomen, a hard mass and protrusion of the naval were present. The abdominal tumor was confined first to the right side but later it occupied the entire abdominal cavity. Rate of growth was moderately rapid and continuous. The patient was examined, including roentgenoscopy of the gastrointestinal tract, by his local physician and the diagnosis was lymphosarcoma. Past and family history irrelevant.

Physical Examination. A normally developed, undernourished white male, subacutely ill and unable to walk. Skin and mucous membrane pale, indicating anemia. Anterior chest and abdominal wall showed enlarged dilated tortuous veins. Abdomen was greatly distended, a hard mass occupying the entire right and medial half of the left abdominal cavity, and the umbilicus was protruded.

Laboratory Findings. Red blood cells 3,680,000; hemoglobin 74 per cent (Sahli); white blood cells 11,600 with 80 per cent neutrophiles and 20 per cent lymphocytes. Urine, specific gravity 1.040, many coarse granular casts.

Roentgen Examination. Gastrointestinal tract was negative except for a displacement which suggested a tumor of the right kidney. Retrograde pyelogram showed right pelvis and calyces to be flattened but not invaded. Right ureter was displaced to the left and was lying lateral to the left ureter. Soft tissue mass obliterated right abdomen and extended over the spine to the left. Liver shadow blended into the tumor. Roentgenograms of the entire skeleton were essentially negative at that time. From these data, a diagnosis of malignant tumor of the right kidney or right suprarenal gland was made. Roentgen irradiation of the right kidney was given—1,000 r, with 200 kv. through each of four anterior portals to the right abdomen. This dose failed to retard even the rate of growth of the tumor and during roentgen treatment several metastatic nodules appeared on the scalp and skull which were revealed by roentgenograms as multiple circumscribed areas of bone destruction (see Fig 4*A*). Biopsy was taken from one of the growths and it showed the typical microscopic picture of neuroblastoma.

FIG. 11. Case II. Marked bone destruction of pelvic bones. Periosteal elevation and some bone destruction of femora. Note rectangular bone spicules and periosteal elevation at lower end of both femoral shafts.

Roentgenograms of the entire skeleton were again taken which were essentially negative though the patient was complaining of pain in the right shoulder and lower abdomen. Roentgenograms of these areas were repeated seven days later and showed many areas of minute destruction and periosteal elevation along the upper epiphyseal end of the humeral shaft. Simultaneously internal strabismus of the right

FIG. 12. Roentgenogram from the Registry on Bone Sarcoma (Registry No. 1705). Bone destruction with marked bone production of the right iliac bone. Microscopic diagnosis: metastatic neuroblastoma.

eye developed, evidently due to intraorbital metastasis. Patient was discharged at the request of the parents on May 14, 1940. We were advised on June 7, 1940, that ptosis and edema of the right eyelid developed soon after the patient left the hospital. At present (August 18, 1940) the patient is still living but his feet and legs have been swollen for the past month. No information, though it was especially requested, was given regarding ocular changes at this time.

CASE VII (Hospital No. 67271). B. L., white female, aged seven, was admitted to the hospital March 11, 1933, complaining of a stiff neck for two and one-half months, also of dropped right wrist and paralysis of right lower extremity. The patient was apparently healthy until December 20, 1932, when she had influenza which lasted about two weeks. Following this she noticed her neck was stiff; there were weakness of right arm and a spastic right leg. On closer questioning, the family admitted that perhaps she had had this stiffness in her neck even before the onset of the influenza.

Physical Examination. A poorly nourished and developed white female, lying with her head bent forward. Eyes, ears, nose and throat normal except for large cryptic tonsils. Neck showed anterior cervical adenopathy; it was stiff and held in one position—limited on motion towards the right. There was a tender mass in the region of fourth cervical vertebra about one-fourth of an inch in diameter, and marked rigidity of neck muscles. Heart, lungs, abdomen and genitalia normal. Left leg and arm were normal; right leg, when walking, had a spastic gait and she dragged her right foot; right arm very weak and hung to the side. Patient was able to raise this arm outward about 10 degrees above level of shoulder. Reflexes showed Babinski positive on right and sustained ankle and patellar clonus on right. Possible diagnosis was Pott's disease of cervical spine or new growth of spinal cord.

Laboratory Findings. Hemoglobin 80 per cent; red blood cells 4,470,000; white blood cells 8,200 with normal differential; urine normal; Wassermann reaction negative. Cerebrospinal fluid clear, heavy globulin, 2 lymphocytes, 10 red blood cells. There was no evidence of spinal block with Queckenstedt test.

With bed rest and splinting of weakest parts; patient improved a great deal and muscle rigidity disappeared. A diagnosis of polioencephalitis was considered for a while but proved false by sensory changes on right side of body. Several agreed it was a cervical cord tumor. On May 20, 1933, a laminectomy was done which revealed a cord tumor from the fourth to sixth cervical segments of the cord.

Microscopical Examination. A tumor composed of scattered, irregular groups of moderately dark staining, small spheroid cells throughout a delicate pink staining reticulum. Blood vessels moderately numerous. Some areas had an abundance of fat globules. There was no capsule and the tumor was poorly circumscribed. Microscopic diagnosis: neurocytoma.

The patient was discharged on June 20, 1933, somewhat improved but readmitted six days later because of pressure sore on back of occiput; however, this healed while in the hospital and patient was again discharged. On

August 12, 1933, she was again admitted to the hospital complaining of pain in shoulder—at this time her condition was very poor. Roentgen therapy was given as palliative measure but the patient died four days later.

Case VIII (Hospital No. 62231). A. R. H., white female, aged fifty-six, was admitted to the hospital May 3, 1932, complaining of pain in her left eye for the past six months. Her local doctor had given her drops, though no improvement was noted. About three weeks prior to admission the eye started to bulge. Patient had been unable to see with this eye for several months. Up to this time her health had been good, otherwise family history was not interesting.

Physical Examination. Head normal. Cornea of left eye was protruding, clouding of media, eye blind and painful. Nose, throat and ears were normal; neck and chest normal. Heart size normal, no murmur and rhythm regular. Blood pressure 200/110. Abdomen had no masses or tenderness. There were small varicose veins in extremities.

Laboratory Findings. Urine normal; hemoglobin 80 per cent; red blood cells 4,150,000; white blood cells 10,100 with normal differential; Wassermann test not done.

Enucleation was advised and done. Gross specimen consisted of eyeball, showing opacity of lens and protrusion along one-half of the cornea with iris pulled in that direction. Cut surface revealed rounded new growth closely covered with retina and filled practically 75 per cent of the eyeball. Lens showed moderately ripe central cataract.

Microscopic Examination. A tumor closely attached to the retina, composed of densely arranged, average sized, moderately pale-staining cells. No pigment within the tumor except the margin next to the retina. Cells had a definite tendency to a rosette formation, giving somewhat of an alveolar-like arrangement to the tumor. Blood vessels not numerous and nuclear material predominant over the internuclear material. Microscopic diagnosis: retinal neuroblastoma.

Postoperative radium treatment was given and patient discharged, but was told to return in six weeks. We have no record of her return.

SUMMARY

Eight cases of neuroblastoma have been presented and the characteristic roentgen signs of their bone metastases have been described.

In the majority of the cases with cranial metastases the sutures are separated; the coronoid suture is most often involved. The cranial bones, particularly the parietals, show innumerable areas of bone destruction varying from pinpoint to several millimeters in diameter. In some cases the sutures are intact and the skull reveals round areas of destruction indistinguishable from those of metastatic carcinoma or sarcoma.

The lesions of the long bones are the most characteristic; they are shown on the roentgenograms as periosteal elevations along the shaft due to subperiosteal hemorrhage or tumor, accompanied by bone destruction starting as minute foci of bone absorption which later become large, confluent, structureless areas. A pathological fracture may occur.

One case in this series (Case VI) with at first a typical Pepper's syndrome, presenting a huge liver and primary tumor of the right adrenal, became converted into a Hutchison's type with metastases to the scalp, skull, humerus and pelvic bones, internal strabismus of the right eye and ptosis and edema of the eyelids. Apparently the growth of the primary tumor was not sufficiently rapid to cause death, allowing the metastatic lesions time to become prominent in the clinical picture.

Many similar cases are recorded in the literature classified as irregular or overlapping types. On the basis of these observations we believe that all neuroblastomas metastasize in an early stage of the primary tumor and they, like all other growths, have slowly and rapidly growing varieties. The metastases remain dormant in the rapidly growing variety (Pepper's type) simply because they lack the sufficient time required to reach an effective and recognizable size, whereas they dominate the clinical picture in case of a slowly growing primary tumor (Hutchison's type).

Those cases classified as "irregular" or "overlapping" types, like our Case VI, are evidently the connecting link between the

Pepper and Hutchison types and suggest that the distinguishing characteristic is the rate of growth of the primary tumor.

REFERENCES

1. BOYD, WILLIAM. Surgical Pathology. Third edition. W. B. Saunders Co., Philadelphia, 1933, p. 159.
2. BOYD, W. Three tumors arising from neuroblasts. *Arch. Surg.*, 1926, *12*, 1031–1048.
3. CAPON, N. B. Neuroblastoma of suprarenal glands. *J. Path. & Bact.*, 1928, *31*, 659–664.
4. COPPEZ, H., SIMON, S., and CLAES, E. Un cas de sympathicoblastome métastatique de l'orbite. *Arch. d'opht.*, 1927, *44*, 193–203.
5. DOANE, J. C., and SOLIS-COHEN, L. Symmetrical adrenal neuroblastoma metastasizing to right auricle. *J. Am. M. Ass.*, 1937, *109*, 578–579.
6. DOUB, H. P. Roentgen aspect of sympathetic neuroblastoma. *J. Am. M. Ass.*, 1937, *109*, 1188–1191.
7. DUNN, J. S. Neuroblastoma and ganglioneuroma of suprarenal body. *J. Path. & Bact.*, 1914–1915, *19*, 456–473.
8. EWING, JAMES. Neoplastic Diseases. Third edition. W. B. Saunders Co., Philadelphia, 1928, pp. 815–819.
9. FREW, R. S. On carcinoma originating in suprarenal medulla in children. *Quart. J. Med.*, 1910–1911, *4*, 123–140.
10. HERXHEIMER, G. Ueber Tumoren des Nebennierenmarkes, insbesondere das Neuroblastoma sympathicum. *Beitr. z. path. Anat. u. z. allg. Path.*, 1913, *57*, 112–117.
11. HILL, H. F. Metastatic orbital tumor. *Am. J. Ophth.*, 1929, *12*, 412.
12. HUTCHISON, R. On suprarenal sarcoma in children with metastases in the skull. *Quart. J. Med.*, 1907–1908, *1*, 33–38.
13. KATO, K., and WACHTER, E. Adrenal sympathicoblastoma in children. *J. Pediat.*, 1938, *12*, 449–462.
14. KUHN, H. S. Adrenal neuroblastoma and its ocular symptoms. *Am. J. Ophth.*, 1939, *22*, 642–648.
15. LANDAU, M. Die malignen Neuroblastome des Sympathikus. *Frankfurt. Ztschr. f. Path.*, 1912, *11*, 26–78.
16. LEDERER, M. Neuroblastoma of adrenal gland. *J. Cancer Research*, 1926, *10*, 377–391.
17. LEHMAN, E. P. Adrenal neuroblastoma in infancy —15 year survival. *Ann. Surg.*, 1932, *95*, 473.
18. LEWIS, D., and GESCHICKTER, C. F. Tumors of the sympathetic nervous system. *Arch. Surg.*, 1934, *28*, 16–58.
19. MARTIUS. Cited by Coppez, ref. 4.
20. MELTZER, SARAH. Neuroblastoma occurring in adults. *Canad. M. Ass. J.*, 1926, *16*, 647–651.
21. PEPPER, W. Study of congenital sarcoma of liver and suprarenal. *Am. J. M. Sc.*, 1901, *121*, 287–299.
22. RANDALL, A., Advantages of pre-operative x-ray in kidney tumor in children. *Ann. Surg.*, 1934, *100*, 462–475.
23. REDMAN, J. L., AGERTY, H. A., BARTHMAIER, O. F., and FISHER, H. R., Adrenal neuroblastoma. *Am. J. Dis. Child.*, 1938, *56*, 1097–1112.
24. RITTER, S. A. Neuroblastoma of small intestine. *Am. J. Surg.*, 1938, *41*, 486–493.
25. RYPINS, E. L. Roentgen diagnosis of neuroblastoma in children. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *37*, 325–332.
26. SEEFELDER, R. Orbitale Metastase eines Neuroblastoma sympathicum. *Arch. f. Augenh.*, 1922, *92*, 7–13.
27. SMITH, J. Case of adrenal neuroblastoma. *Lancet*, 1932, *2*, 1214–1215.
28. STARTZ, I. S., and ABRAMS, J. Neuroblastoma; childhood type of malignant tumor of sympathetic nervous system. *Radiology*, 1938, *30*, 232–241.
29. SYMMERS, D. Recurrent neuroblastoma of scapular region. *J. Am. M. Ass.*, 1913, *60*, 337–340.
30. WAHL, H. R. Neuroblastomata. *J. Med. Research*, 1914, *30*, 205–260.
31. WAHL, H. R., and CRAIG, P. E. Multiple tumors of sympathetic nervous system. *Am. J. Path.*, 1938, *14*, 797–808.
32. WEICHSELBAUM, A. Ein ganglioses Neuron des Nebenniere. *Virchow's Arch. f. path. Anat.*, 1881, *85*, 554.
33. WESSELY, K. Ein bisher noch nicht beschriebener Fall von Orbitaltumor. *Arch. f. Augenh.*, 1919, *85*, 57.
34. WIESEL, J. Bemerkungen zu der Arbeit H. Küsters: Ueber Gliome der Nebennieren. *Virchow's Arch. f. path. Anat.*, 1905, *180*, 553–555.
35. WRIGHT, J. H. Neurocytoma or neuroblastoma, a kind of tumor not generally recognized. *J. Exper. Med.*, 1910, *12*, 556–561.

Vol. 46, No. 6

HODGKIN'S DISEASE INVOLVING THE STOMACH

REPORT OF TWO CASES

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IN 1913 Schlagenhauffer described gastric granuloma without involvement of other organs. Since then numerous investigators, chiefly European, have described various forms of gastrointestinal Hodgkin's disease. Terplan stated in 1922 that he believed that previous to 1913 the localized form of lymphogranulomatosis of the gastrointestinal tract was frequently classified as sarcoma of the bowel or tuberculous enteritis.

Hodgkin's disease has been classified under various names. Wallhauser, in a general review of Hodgkin's disease in 1933, listed fifty-one different terms that have been used to describe this disease. The different anatomical classifications of Hodgkin's disease by pathologic anatomists proves that the histological interpretation of this disease is not always easy. It has been classified by various pathologists under the following groups: (1) a nonspecific infectious granuloma; (2) a neoplasm; (3) a disease occupying an intermediate position between chronic generalized infectious diseases and the blastomata.

Gastrointestinal Hodgkin's disease is not a sharply circumscribed anatomic form of this disease. The disease may manifest itself as a single tumor involving some portion of the gastrointestinal tract or there may be extensive and multiple ulcers, alone or associated with enlargement of several groups of lymph glands.

In 1927 Hayden and Apfelbach reviewed the literature on gastrointestinal Hodgkin's disease rather extensively. They reviewed 26 previously reported cases. Of these cases, in 3 the stomach alone was involved, in 10 the small bowel alone was involved, and in 10 stomach, small bowel and large bowel were involved, and in 3 the large bowel alone was involved. They then presented 3 new cases that they themselves had studied. From this review the following conclusions were reached:

(1) Infiltrations of the gastrointestinal tract are characterized by gray, translucent, adenoid-like tissue and frequently by ulcerations. Infiltrations are variable in size and are usually multiple.

(2) Histological findings are similar to those seen in other forms of the disease.

(3) Most common clinical findings are diarrhea, abdominal pain, rapid cachexia, secondary anemia, leukopenia or normal leukocyte count and fever. The most common variation in the differential blood count was an actual decrease in lymphocytes and a slight eosinophilia. Occult blood in the stools was uncommon.

(4) Most common causes of death were cachexia, generalized peritonitis from perforation of ulcers and acute anemia from hemorrhage.

(5) Obstacles to correct clinical diagnosis are many considering the following factors:
   (a) the infrequency of the disease
   (b) lack of specific diagnostic tests except histologic examination
   (c) the multiplicity of gastrointestinal alterations
   (d) the lack of enlargement of superficial lymph nodes and the spleen so characteristic of the common clinical conception of Hodgkin's disease

(6) The conditions to be considered in differential diagnosis in order of frequency are ulcerative enteritis and colitis particularly tuberculous, gastric carcinoma, and bowel obstruction.

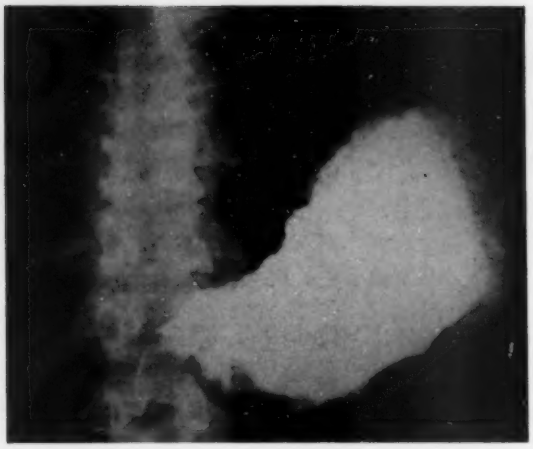

FIG. 1. Case 1. Barium filled stomach showing irregular filling defect involving the distal half of the stomach.

The etiology of Hodgkin's disease has never been determined and all attempts to transmit the disease experimentally have failed. The following theories of etiology have been advanced: (1) an atypical form of tuberculosis; (2) a specific infection by a diphtheroid bacillus; (3) a granuloma of unknown etiology; (4) a neoplastic disease.

FIG. 2. Case 1. Oblique projection of Figure 1.

In 1931 Singer reviewed 6 cases of Hodgkin's disease previously reported by other investigators in which the stomach alone was involved. He reported another similar case studied by himself. The roentgenogram in this case showed a constant annular deformity involving the pars pylorica and the distal portion of the pars media which was interpreted as carcinoma.

In those cases from the literature in which roentgen studies were carried out, the most constant gastric finding seemed to be an irregular filling defect which was interpreted as a carcinoma.

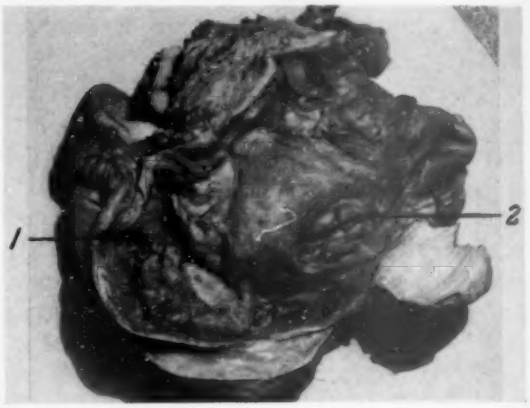

FIG. 3. Case 1. Photograph of stomach specimen showing massive, extensive infiltration. *1*, pylorus; *2*, gastroenterostomy opening.

REPORT OF CASES

CASE 1. B. E., aged fifty-six, male. Occupation, travel manager. Admitted September 6, 1938.

History. Eight year history of intermittent attacks of nausea and emesis which would occur almost immediately following eating. Since February, 1938, nausea and emesis had been frequent and gradually increasing. Never any pain. Increasing malaise and weakness. Loss of 63 pounds in two years, 30 of which had been since February, 1938. No history of tarry stools or blood in emesis.

Physical Examination. Patient appeared to have lost considerable weight. Hard, irregular, non-tender mass in the epigastrium which followed outline of the stomach.

Laboratory Findings. Blood—red blood count 3,420,000; hemoglobin 46 per cent; white blood

count 21,490; differential—moderate left shift. Urea, glucose and sodium chloride normal. Stools, positive for blood on three occasions.

Roentgen Findings. Stomach after barium by mouth showed an irregular filling defect involving distal half of the stomach and pylorus with fixation and rigidity of the wall. Large five hour residue. Roentgen interpretation—malignant new growth involving entire wall of the distal half of the stomach.

Surgical Findings. Firm irregular mass involving the lower end of the stomach. Lower two-thirds of the posterior wall was involved. Lower anterior wall of the stomach spotted with firm hard masses of varying size. Firm discrete masses in omentum, one of which was removed for biopsy. Anterior gastroenterostomy and jejunojejunostomy performed.

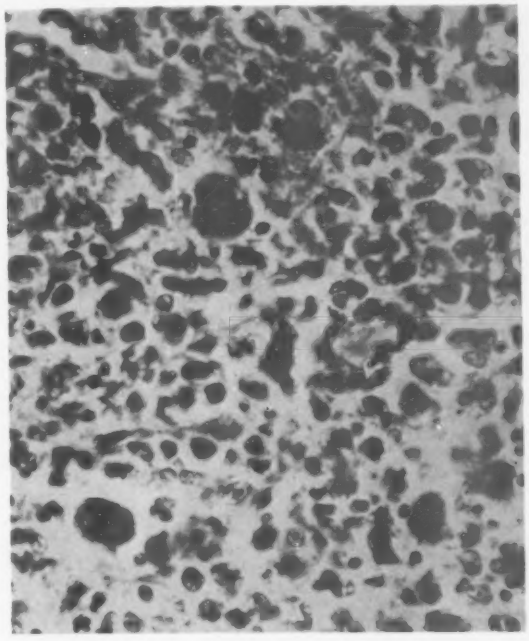

Fig. 4. Case 1. Photomicrograph of section from stomach.

Pathological Report on Biopsy. Histological findings correspond to Hodgkin's disease with very marked leukocytic inflammation.

Course. Patient discharged from hospital October 4, 1938, to private physician. Returned October 11, 1938, following severe hematemesis. Patient died on October 13, 1938. Autopsy was performed.

Autopsy Findings. Status following gastroenterostomy and jejunojejunostomy. Hodg-

Fig. 5. Case 11. Barium filled stomach in upright position showing massive filling defect involving the distal half of the stomach.

Fig. 6. Case 11. Roentgenogram taken in prone position showing involvement similar to that seen in Figure 5.

FIG. 7. Case II. Five hour film showing considerable gastric retention.

kin's disease involving the stomach with several ulcerating areas. Mucosa distinctly thickened. Massive recent hemorrhage in stomach. Hodgkin's disease involving duodenum with ulceration. Hodgkin's disease involving abdominal lymph nodes. Hodgkin's nodules in liver varying from pinhead to cherry size. Thrombus formation in anterior descending branch of left coronary artery.

CASE II. C. B., aged twenty-seven, female, unemployed. Admitted April 30, 1938.

History. Head cold and sinusitis five weeks prior to admission. Two weeks later developed small, raised, firm reddened, tender, hot areas over both legs. Areas would subside only to be replaced by new similar areas of swelling. Afternoon temperature up to 100° F. since onset. Increasing weakness and anorexia. Loss of weight from 107 to 100 pounds.

Physical Examination. Emaciated. Over the legs from knees to feet were many raised, indurated, reddened, tender areas varying in size from ½ inch to 2 inches in diameter. Some lesions were recent while others were subsiding. Pharynx was moderately injected. Otherwise, physical examination was essentially negative.

Laboratory Findings. White blood count 17,000; differential, moderate left shift.

Course. Patient was seen by the staff of the dermatology service who made a diagnosis of erythema nodosum on the skin lesions. The skin lesions cleared completely in about two weeks. However, patient continued to run an afternoon temperature up to 101° F. Anorexia and malaise persisted and patient began to complain of aching pain through the upper abdomen. Repeated blood cultures were sterile. White blood count remained about the same as on admission. Agglutination tests for typhoid, paratyphoid, and undulant fever were negative. Patient gradually lost weight and there were no changes in physical findings until July 27, 1938, when a firm mass was felt in the epigastrium. Weight on August 15, 1938, was 74½ pounds. Occult blood was never found in the stools. On August 18, 1938, gastrointestinal tract was studied roentgenologically.

Roentgen Findings. Stomach was low in the abdomen and partially fixed. Irregular filling defect involved the pyloric end of the stomach with rigidity of the entire wall. Moderate five hour residue. Remainder of gastrointestinal tract negative. Roentgen interpretation—malignant growth involving the wall of the distal half of the stomach.

Gastroscopic Findings. August 25, 1938. Distal half of stomach involved in a proliferative

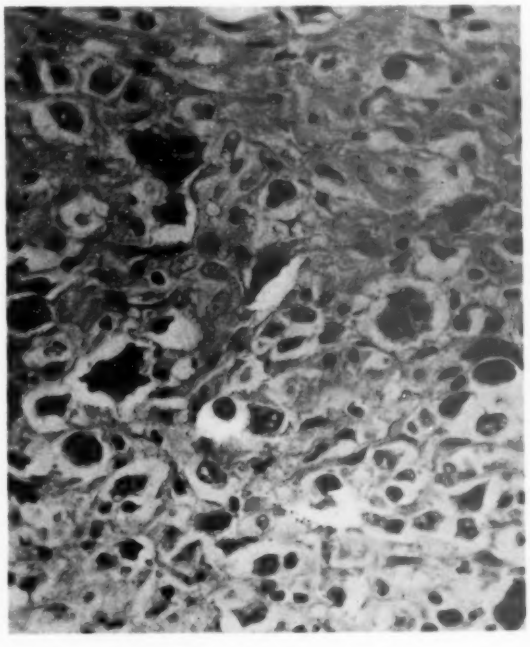

FIG. 8. Case II. Photomicrograph of section from the stomach.

indolent appearing lesion with interrupted areas of breaking down. Several areas of ulceration on posterior wall with considerable heavy mucus between. Interpretation was malignant lesion—possibly chronic granuloma of some type.

Operative Findings. September 3, 1938. Entire stomach involved in tumor mass. Large metastases in liver. Biopsy taken from anterior stomach wall.

Pathology Report. Hodgkin's disease of the blastomatous type with many giant cells and many mitotic figures.

Postoperative Course. Patient received roentgen therapy in moderate doses postoperatively but it did not seem to have any effect on the disease. She grew progressively worse and died November 6, 1938. No autopsy performed.

DISCUSSION

We have reported these 2 cases with one chief purpose in mind, that is to see if there are any characteristic roentgen findings in Hodgkin's disease involving the stomach. From the pathology of the process we would expect findings similar to those seen in other infiltrative, ulcerative lesions involving the wall of the stomach, such as neoplasms or chronic granulomatous processes and this we find is the case. In both cases which we examined there was diffuse, extensive involvement of the wall of the stomach with rigidity and considerable encroachment on the lumen resulting in quite marked gastric retention. The distal half of the stomach was the part involved in both cases. Probably the most striking thing noted in both instances was the extent of the involvement of the gastric wall.

CONCLUSIONS

We have presented two cases of Hodgkin's disease involving the stomach. Chief roentgenographic findings are:

(1) Encroachment on the lumen of the stomach by infiltration in the stomach wall.
(2) Rigidity of the stomach wall.
(3) Areas of ulceration may or may not be present.
(4) From the literature on this subject it would seem that the amount and distribution of the gastric involvement are extremely variable.

There do not seem to be any roentgenologic differences between Hodgkin's disease and other infiltrative, ulcerative lesions involving the stomach.

REFERENCES

1. Hayden, Helen C., and Appelbach, C. W. Gastro-intestinal lymphogranulomatosis. *Arch. Path. & Lab. Med.*, 1927, *4*, 743–770.
2. Singer, H. A. Primary, isolated lymphogranulomatosis of the stomach. *Arch. Surg.*, 1931, *22*, 1001–1017.
3. Terplan, K. Ueber die intestinale Form der Lymphogranulomatose. *Virchow's Arch. f. path. Anat.*, 1922, *237*, 241.
4. Wallhauser, A. Hodgkin's disease. *Arch. Path.* 1933, *16*, 522; 672.

INTUSSUSCEPTION

REPORT OF UNUSUAL ADULT CASE

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SINCE intussusception is the product of faulty mechanical activity rather than a distinct disease entity, it is to be expected that there would be wide variation in the etiological factors resulting in this activity. Occasionally the etiology remains undetermined since no other pathological conditions can be found. In the case reported below the cause was found only after a careful search at operation.

CASE REPORT

F. R., white female, aged thirty-one, secretary, was referred* for a gastrointestinal study on January 23, 1940. In July, 1939, the patient had an attack of severe right upper abdominal pain. Several less severe attacks occurred subsequently. During the past week cramp-like non-radiating pain recurred intermittently in the right loin. The pain tended to return about fifteen minutes after meals and seemed to "leave and return" intermittently during the day. The periods of attack were associated with pain in the lumbar region. The patient complained that recently, while sleeping on the abdomen, she "feels as if a pressure is exerted on the abdomen." Obstipation was becoming progressively worse so that three to seven days elapsed between defecation. Patented laxatives were resorted to frequently. The feces, besides being hard and hence causing rectal pain, were normal in all other respects.

Thorough interrogation revealed that besides being allergic to dust and dog-hair there were no other complaints exclusive of the present illness. The patient had seldom been sick other than for an attack of catarrhal jaundice at age sixteen and constipation throughout life. There was no history of operations nor serious accidents. The family history was irrelevant.

On physical examination it was found that the weight was 130 pounds; blood pressure, 120/90; hb, 82 per cent (Dare); temperature, 98.3° F.; pulse 96 per minute, regular and of good quality. The head and neck revealed no pathological findings other than hypertrophy of both middle turbinates. The heart and lungs presented no unusual findings. On abdominal examination tympany was present over the right loin and the entire left side; there was no tenderness nor rigidity; no masses were felt. Rectal inspection revealed second degree hemorroids. Vaginal examination was refused.

Roentgenological study of the colon was decided upon and in view of the observations no further study was deemed necessary. The findings were as follows: Barium taken per os: at nine, twenty-four, and forty-eight hours the head of the barium column was in the hepatic flexure and the tail in the cecum. The appendix was not visualized. It will be noted in the accompanying roentgenograms that at twenty-four hours a small amount of barium was located at the distal transverse colon and on the following day returned to the proximal end. Since no defecation occurred during the study, this finding indicated that antistalsis had taken place. Barium enema study: entrance of the barium stream was delayed at the hepaticotransverse colon junction. At this site a convexity to the right developed with about $1\frac{1}{2}$ inches of the transverse colon intussuscepting into the hepatic flexure. This was released by slight manipulation and the solution continued to flow down to the cecum. During roentgenoscopy the intussusception redeveloped and spontaneously released itself several times. Attempt at evacuation of the contrast medium resulted in its retention in the segment proximal to the affected part. On slight pressure the obstruction was overcome and a moderate amount of the barium could be seen squirting through. Accordingly, roentgenograms before and after evacuation did and at times did not demonstrate the intussusception. At no time was a neoplasm discernible. A diagnosis was made of chronic spontaneously reducing and relapsing intussusception with retrograde peristalsis involving the hepaticotransverse colonic junction.

To avoid complications, surgical intervention was suggested. This procedure was carried out February 6, 1940, by Dr. Harold Draffen at the

* Appreciation is hereby expressed to Dr. Daniel Porte for the courtesy extended.

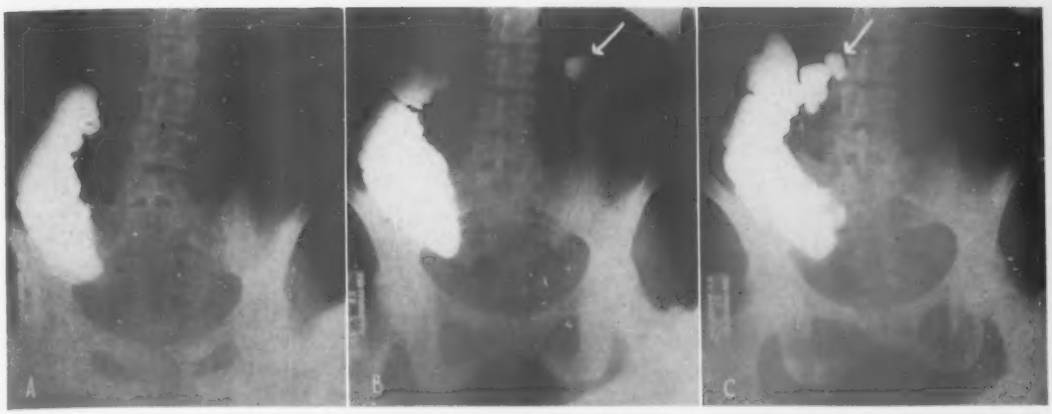

Fig. 1. Partial obstruction at hepatic flexure. (*A*) nine hour study; (*B*) twenty-four hour study. Bolus of barium at arrow; (*C*) forty-eight hour study. Bolus returned to barium column indicating antistalsis.

Mary Immaculate Hospital, Jamaica, New York. The surgeon's report was as follows: "Uterus, tubes, ovaries, and appendix grossly normal. The small intestines presented no pathological findings. Gallbladder thin, emptied easily; there were no calculi. The proximal end of the transverse colon easily invaginated into the hepatic flexure, but reduced itself spontaneously. The hepaticotransverse colonic junction was demarcated by a moderate thickening (about 1/16 inch wide) around its circumference. Except for a tough band of fibrous tissue (about $\frac{1}{4}$ inch wide) extending from the right lateral abdominal wall to the lateral border of the mid-hepatic flexure, no other pathological conditions were found after careful search. Hepatic flexure was freed. A small opening was made through the gastrocolic omentum and through this opening the mid-portion of the transverse colon was sutured to the upper left anterior abdominal wall . . . appendix amputated." Post-operative diagnosis: "Recurrent intussusception of colon caused by fibrous band (of undetermined origin) between abdominal wall and hepatic flexure."

After an uneventful recovery, the patient was discharged from the hospital on February 17, 1940. Subsequently (up to July 14, 1940) there were no gastrointestinal complaints except a moderate degree of constipation which was controlled by a psyllium seed preparation. Roentgenological restudy, starting on February 27, 1940, revealed that the head of the barium column reached the rectum at nine hours. There was a persistent narrowing at the mid-hepatic flexure where the fibrous band had previously been attached. Barium enema study revealed a slight delay in the passage of the opaque solution at the site of the transverse colon surgically fixed. There was no evidence of intussusception.

Fig. 2. Barium enema study. (*A*) intussusception of proximal transverse colon into hepatic flexure; (*B*) roentgenogram taken a few seconds later indicating spontaneous reduction; (*C*) after enema evacuation barium remains in colon proximal to recurred intussusception.

DISCUSSION

Review of Literature. It has been suggested[6] that the generally reported average of 95 per cent intussusceptions occurs in children because their intestinal lumen is relatively narrow with the mucosal folds excessively developed and studded with lymphoid follicles. During intestinal disturbances these follicles may become edematous and with a colicky contracture may result in intussusception. Since these factors are in reverse development as children grow older, Hinton[6] further suggests that development as the explanation for the less frequent occurrence of intussusception in adults. There appears to be a marked preponderance of male over female cases (two[9] to six[10]:one) in children, with some of the predisposing factors being invagination of Meckel's diverticulum, chronic enteritis, numerous and swollen mesenteric glands, typhoid fever, hyperplastic follicles of Peyer's patches, and movable cecum.

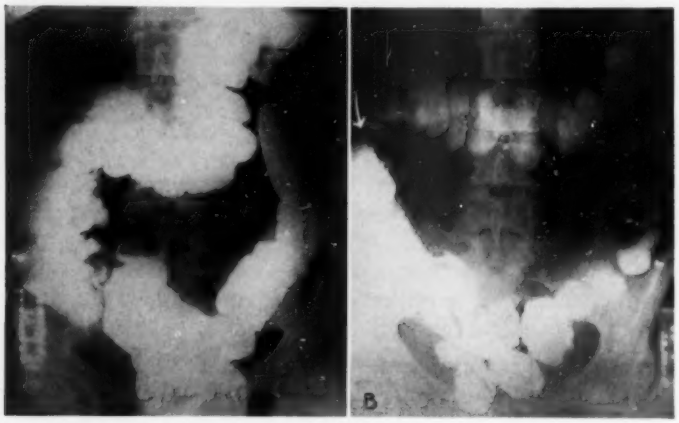

FIG. 3. After operation. (*A*) barium enema study; no intussusception; (*B*) nine hour study. Head of barium column in rectum. Arrow indicates narrowed lumen where fibrous band was attached.

Contrary to the observations in children, intussusception in adults tends to be of the subacute or chronic variety, frequently caused by abnormalities of the intestines or, in about 33.3 per cent of reported cases[3,5] by tumors. Mooro[8] reported 2 acute cases in adult Mohammedans occurring after a holiday fast of about sixteen hours. Unpreceded by food, one of these patients drank cold water which might have induced intestinal hyperperistalsis with a resultant intussusception. In his second case the starvation is suggested as the exciting factor. Macdonald[7] and Starlinger[10] each record a case associated with a Meckel's diverticulum. In Macdonald's case a benign polyp was present in the diverticulum. Starlinger's patient presented a volvulus above and invagination below the diverticulum. One of Christopher's[1] cases revealed no definite cause of the intussusception involving the ileocecal valve. Collins[2] recorded a case of colocolic intussusception resulting from extensive chronic dysenteric ulceration. In that instance, as was also brought out in my case report, spontaneous reduction and relapse occurred. Cutler[4] added to the literature a case of transverse colon intussusception which demonstrated hypertrophy of the mucosa and marked chronic and acute inflammatory changes with superficial ulceration. Christopher[1] mentions nine other authors as having recorded intussusceptions into gastroenterostomy stomata. To this group may be added one of Starlinger's[10] cases.

Types. The appendix rarely intussuscepts into the cecum. This faulty mechanical activity may involve only the colon or small intestine or a portion of the small intestine may intussuscept into the cecum. The latter is the most common type found in children. The intussuscepted mass may be simple or compound. The compound type may have invaginations at both the

proximal and distal ends of a portion of gut with this mass being further invaginated into another intussuscepiens.

Symptoms. Intermittent attacks of localized abdominal pain associated with severe constipation should excite the attention as to the possibility of the presence of a spontaneous reducing and relapsing intussusception. The obstructive symptoms, having so frequently been described, do not herein warrant repetition.

Treatment. With rare exception, early surgical intervention for disinvagination gives the desired results in children. Other procedures are fraught with danger. Resection is advised against[10] in children and in early cases associated with acute ileus in adults. Hinton[6] believes that in all cases of ileocecal region intussusception the appendix should be removed. Starlinger,[10] however, mentions that one of the causes of intussusception in children is "conditions after appendectomy."

Prognosis. The prognosis in children is governed by the duration of the disease and age of the child; in adults, by existence and duration of acute intestinal obstruction and type of neoplasm.

CONCLUSIONS

(1) A case is reported of chronic spontaneous reducing and relapsing intussusception of the transverse colon into the hepatic flexure (retrograde peristalsis) in an adult female. This activity was observed on roentgenological study. The etiological factor, found at operation, was a fibrous band extending from the right lateral abdominal wall to the mid-hepatic flexure.

(2) Localized abdominal pain recurring intermittently and associated with severe persistent constipation suggests the possibility of chronic reducing and relapsing intussusception.

(3) Early surgical intervention in all cases of intussusception is the procedure of choice.

REFERENCES

1. Christopher, F. Intussusception in adults. *Surg., Gynec. & Obst.*, 1936, *63*, 670–674.
2. Collins, F. M. Case of colo-colic intussusception due to dysenteric ulceration. *Brit. J. Surg.*, 1939, *27*, 144–148.
3. Costa, G. Nuovi contributi clinici allo studio delle invaginazioni intestinali in persone adulte. *Arch. ital. di chir.*, 1932, *32*, 237–316.
4. Cutler, C. W., Jr. Non-malignant intussusception of transverse colon in adult. *Ann. Surg.*, 1929, *90*, 293.
5. Eliot, E., Jr., and Corscaden, J. A. Intussusception, with special reference to adults. *Ann. Surg.*, 1911, *53*, 169–222.
6. Hinton, J. W. Acute primary intussusception in adult. *Ann. Surg.*, 1926, *84*, 100–103.
7. Macdonald, I. Intussusception in adult due to polyp of Meckel's diverticulum. *Brit. M. J.*, 1928, *1*, 442.
8. Mooro, A. W. Acute intussusception in adults during a fast. *Brit. M. J.*, 1924, *1*, 319.
9. Perrin, W. S., and Lindsay, E. C. Intussusception. *Brit. J. Surg.*, 1921, *9*, 46–71.
10. Starlinger, F. Darmverschluss durch Invagination beim Kinde und beim Erwachsenen. *Wien. klin. Wchnschr.*, 1931, *44*, 143–145.

STRUCTURAL DEFORMITIES OF THE SPINE FOLLOWING BILATERAL LAMINECTOMY

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PHILADELPHIA, PENNSYLVANIA

THE purpose of this communication is to call attention to a painful deformity observed in the lumbar region of the spine in 3 cases and in the dorsal region of the spine in one case following bilateral laminectomy. These patients returned for observation from eight months to fifteen years after bilateral laminectomy involving from two to five vertebrae, in which the spinous processes and the laminae on both sides had been removed, but the articular facets had been preserved. They complained of a variable amount of pain, weakness and fatigue in the back, and they presented obvious deformity associated with changes in the intervertebral discs and vertebral bodies in the region of the laminectomy. A similar deformity has been reported by Taylor[7] following bilateral laminectomy in the cervical spine.

CASE 1. A male, aged twenty, had had a bilateral laminectomy (first and second lumbar vertebrae) in an effort to relieve the residual vesical and rectal incontinence and the sensory changes in the lower limbs, which had followed a compression fracture of the first lumbar vertebra sustained sixteen months previously. Despite the application of a back brace postoperatively, he experienced increasing discomfort, fatigue and a sense of weakness in the laminectomized area. When examined two years postoperatively, he presented a marked gibbus at the level of the twelfth dorsal vertebra, tenderness over the operative site, paraspinal muscle spasm and limited motion of the dorsolumbar

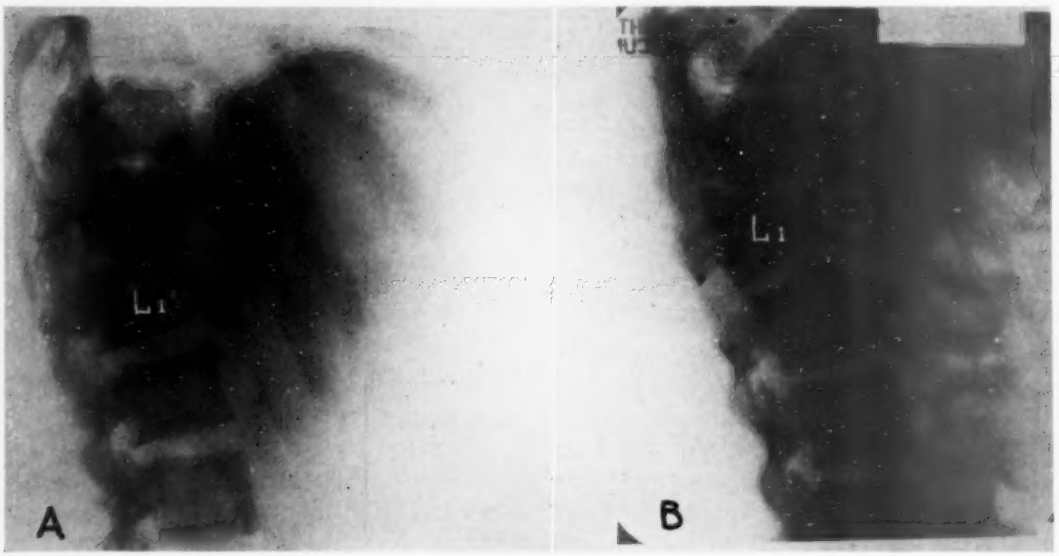

FIG. 1. Case 1. *A*, lateral view of the dorsolumbar vertebrae just prior to bilateral laminectomy (first and second lumbar). There is anterior wedging of the body of the first lumbar vertebra due to a compressed fracture incurred sixteen months previously. The intervertebral disc between the twelfth dorsal and first lumbar vertebrae is slightly narrowed.

B, lateral view two years after operation. The wedging of the first lumbar body is unchanged. There is increase in the pre-existing kyphosis at this level, with narrowing of the intervertebral discs between the twelfth dorsal and first lumbar and between the first and second lumbar vertebrae and marginal bony proliferation between the first and second lumbar bodies. A large renal calculus (left pelvis) is present.

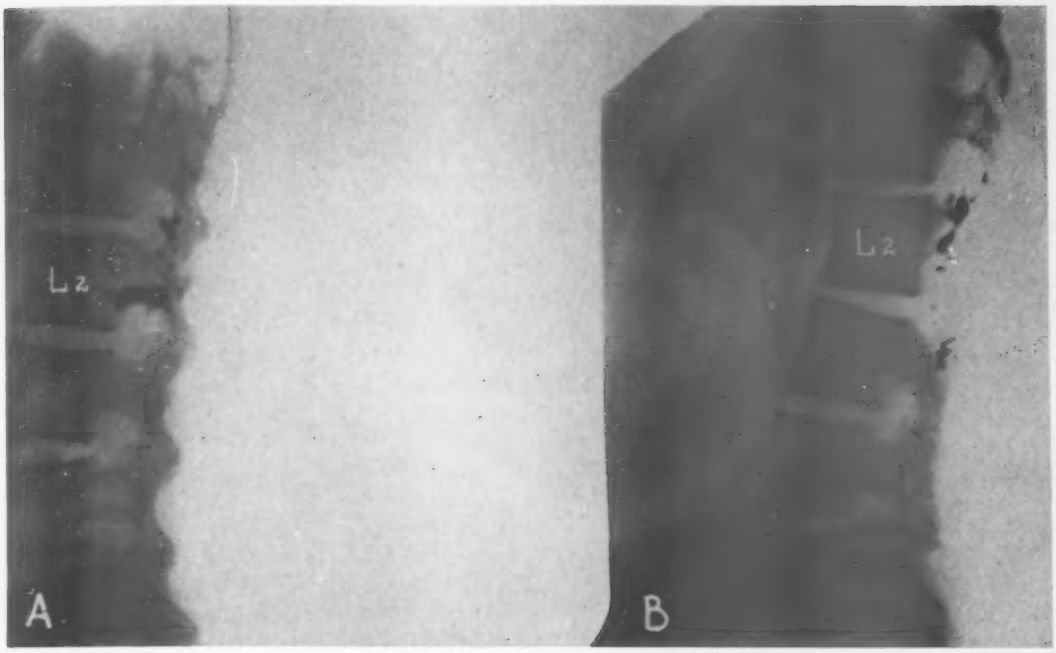

Fig. 2. Case II. *A*, lateral view of the dorsolumbar vertebrae just prior to bilateral laminectomy (second and third lumbar). There are no changes in the vertebrae or intervertebral discs. The lipiodol column is completely blocked at the level of the second lumbar segment.

B, lateral view eighteen months after operation. There is a kyphosis at the level of the second and third lumbar vertebrae with narrowing of the intervertebral disc and early marginal bony proliferation between the second and third lumbar vertebral bodies.

spine. Comparison of the preoperative roentgenograms of the lumbar spine (Fig. 1*A*) and the postoperative films made two years later (Fig. 1*B*) revealed an increase in the pre-existing kyphosis at the level of the first lumbar vertebral body, and narrowing of the intervertebral discs with marginal bony proliferation between the twelfth dorsal and first lumbar and between the first and second lumbar vertebrae. A large left renal calculus was evident in the lateral roentgenograms.

An Albee spine fusion (eleventh dorsal to third lumbar vertebrae) was performed, and three months later the calculus was removed from the left renal pelvis.

Case II. A female, aged sixteen, had had a bilateral laminectomy (second and third lumbar vertebrae) for the excision of an intraspinal neurofibroma. Preoperative roentgenograms had revealed the osseous components of the dorsal and lumbar spine to be normal (Fig. 2*A*). She wore no external support postoperatively and was free of symptoms for one and one-half years until a direct injury to her back initiated constant and severe pain at the site of operation. When examined two months after this trauma, she presented a gibbus at the level of the first lumbar vertebra, exquisite tenderness of the soft tissues about the operative site, lumbar muscle spasm and limited spinal mobility. Neurological and spinal fluid examinations were negative. Roentgenograms at this time revealed a kyphosis at the level of the second and third lumbar vertebrae, with narrowing of the intervertebral disc anteriorly and marginal bony proliferation between the second and third lumbar vertebral bodies (Fig. 2*B*).

A spine fusion was recommended but was refused by the patient. She has been relieved by the application of an external support.

Case III. A male, aged forty-five, had had a bilateral laminectomy (twelfth dorsal to fourth lumbar vertebrae) for the excision of an intraspinal dermoid tumor. He wore no external support and four years postoperatively, without injury, he began to experience constant and increasing discomfort in the lower back. The presence of some abnormal sensory and motor

Fig. 3. Case III. Lateral view of the dorsolumbar spine taken fifteen years after bilateral laminectomy (twelfth dorsal to fourth lumbar). There is a kyphosis at the level of the twelfth dorsal and first lumbar vertebrae with narrowing of the intervertebral discs and marginal bony proliferation between the vertebral bodies at this level.

findings several years later had suggested the possibility of a recurrence of the intraspinal lesion and he had been given a brief course of roentgen therapy. When examined fifteen years postoperatively, the patient presented a gibbus at the dorsolumbar juncture, limitation of spinal mobility and lumbar muscle spasm. The initial roentgenograms, taken preoperatively in 1925, have been destroyed, but a competent roentgenologist had reported: "There is no alteration in the bony architecture or the positional relations of the lumbar vertebrae to each other, nor do we observe any bone lesion at present." Roentgenograms fifteen years postoperatively (Fig. 3) revealed a kyphosis at the level of the twelfth dorsal and first lumbar vertebrae with narrowing of the intervertebral discs and marginal bony proliferation between the twelfth dorsal and first lumbar and between the first and second lumbar vertebral bodies.

The patient has been institutionalized because of a mental condition, and a back brace has been recommended.

Case IV. A male, aged forty-eight, had had an exploratory laminectomy (fourth to seventh dorsal vertebrae) which had revealed an inoperable degenerative lesion of the spinal cord at this level. The patient had become increasingly incapacitated by the progressive transverse cord lesion but he remained ambulatory. Following the laminectomy he began to experience moderate discomfort in the upper back. When examined eight months postoperatively, he demonstrated an exaggeration of the normal kyphosis in the upper dorsal region of the spine. There was slight tenderness and paraspinal muscle spasm in the region of the laminectomy. A comparison of the roentgenograms of the dorsal spine prior to the operation (Fig. 4*A*) and those taken eight months postoperatively (Fig. 4*B*) revealed an increase in the kyphosis of the upper dorsal spine in the region of the laminectomy, with narrowing of the intervertebral discs at this level but without alteration in the bony architecture.

No orthopedic measures were instituted in view of the patient's debilitated condition.

COMMENT

Taylor[7] and Adson and Ghormley[1] have reported that bilateral laminectomy in the cervical spine may give rise to dislocation and deformity of the cervical vertebrae. For this reason the use of unilateral (hemi-) laminectomy has been recommended in this region, whenever feasible (Taylor,[7] Stookey,[6] Rasmussen, Kernohan and Adson,[5] Craig and Shelden[2]). To my knowledge, similar postlaminectomy deformities have not been recorded in the dorsal and lumbar regions of the spine prior to this report. Only 5 cases in a series of 25 bilateral laminectomies were available for this study. Four of these 5 cases demonstrated the painful spinal deformity herein described. The fifth case, a twenty-seven year old female, had a bilateral laminectomy (fourth and fifth lumbar vertebrae) nine months ago for a suspected intraspinal lesion, and, as yet, is asympto-

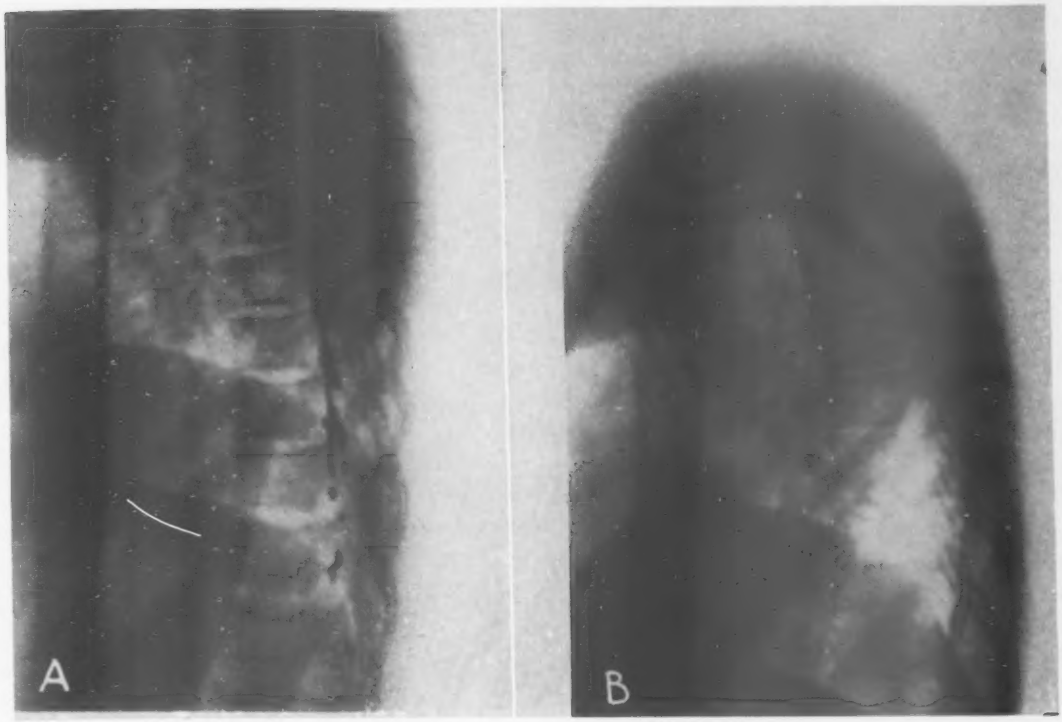

Fig. 4. Case iv. *A*, lateral view of the normal dorsal spine just prior to bilateral laminectomy (fourth to seventh dorsal) *B*, lateral view eight months postoperatively. There is an increase in the kyphosis of the upper dorsal spine in the region of the laminectomy, with narrowing of the intervertebral discs at this level, but without alteration in the bony architecture.

matic and gives no evidence of spinal deformity, either clinically or roentgenographically.

The use of immediate or delayed spine fusion following laminectomy, in the absence of a weakened or diseased vertebral column, has been considered unnecessary by most neurosurgeons. However, an increasing number of orthopedic surgeons are favoring the use of spine fusion in conjunction with the laminectomy. It is my opinion that one of the indications for immediate spine fusion following bilateral laminectomy, the patient's condition permitting, is the prevention of such symptomatic deformities as have been reported by Taylor in the cervical spine, and as have been demonstrated in the dorsal or lumbar portions of the spine in my cases. It also appears important that those patients who are subjected to bilateral laminectomy without immediate spine fusion should have periodic roentgenograms of the spine in order to ascertain the development of spinal deformity and of secondary bone and soft tissue changes. Delayed spine fusion in such cases is technically more difficult than spine fusion at the time of laminectomy, and the vertebral changes which have developed are permanent. It is possible that hemilaminectomy (Taylor), partial laminectomy with preservation of the neural arch (Love and Walsh[4]) and the interlaminar approach (Love[3]) may obviate the need for spine fusion, but the use of these procedures, especially of the latter two, is restricted because of their limited exposures.*

* Barr and Mixter, who advocate the use of spine fusion at the time of laminectomy for posterior disc protrusion if marked abnormal mobility is demonstrated at the site of the lesion, if the laminectomy is extensive, or if an articular facet has been sacrificed, report that, in a series of 94 cases followed for one year or more, 73 per cent of the patients having fusion (33) considered their backs of normal strength, whereas only 52 per cent of those without fusion (61) had no complaints. (Barr, J. S., and Mixter,

CONCLUSIONS

Symptomatic spinal deformity may appear and pre-existing spinal deformity may become aggravated following bilateral laminectomy in the cervical, thoracic and lumbar regions of the spine, even when the articular facets are preserved. It is suggested that such deformities may be prevented by the performance of a spine fusion immediately following the laminectomy. In those cases in whom immediate internal fixation of the spine is not employed, periodic roentgenography is advisable for the early diagnosis of secondary deformity and degenerative changes, and such cases should be treated by external fixation or more effectively by spine fusion.

Acknowledgment: Cases III and IV have been studied by permission of Dr. Thomas A. Shallow.

W. J. Sciatic pain in low-back derangements: its incidence, significance, and treatment; symposium; posterior protrusion of the lumbar intervertebral discs. *J. Bone & Joint Surg.*, 1941, *23*, 444–456.)

REFERENCES

1. Adson, A. W., and Ghormley, R. K. Fixation of the spine for dislocation following removal of a high-lying tumor of the cervical portion of the spinal cord. *Proc. Staff Meet., Mayo Clin.*, 1933, *8*, 297–300.
2. Craig, W. M., and Shelden, C. H. Tumors of the cervical portion of the spinal cord. *Arch. Neurol. & Psychiat.*, 1940, *44*, 1–16.
3. Love, J. G. Protruded intervertebral disks, with a note regarding hypertrophy of the ligamenta flava. *J. Am. M. Ass.*, 1939, *113*, 2029–2034.
4. Love, J. G., and Walsh, M. N. Intraspinal protrusion of intervertebral disks. *Arch. Surg.*, 1940, *40*, 454–484.
5. Rasmussen, T. B., Kernohan, J. W., and Adson, A. W. Pathologic classification, with surgical consideration, of intraspinal tumors. *Ann. Surg.*, 1940, *111*, 513–530.
6. Stookey, B. Compression of spinal cord and nerve roots by herniation of nucleus pulposus in the cervical region. *Arch. Surg.*, 1940, *40*, 417–432.
7. Taylor, A. S. Hemilaminectomy. *Tr. Am. Neurol. Ass.*, 1927, *53*, 524–544.

Vol. 46, No. 6

TOTAL CONGENITAL ABSENCE OF THE TIBIA

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THIS is the rarest of congenital deformities. Thorough search of the literature with a check of the bibliographies given by those reporting cases reveals only 89 instances of the condition. We found some references in which doubtful cases and cases of partial absence of the tibia were included with those of total absence.

We are reporting a case of our own, giving a report of a recent check-up of Myers' case, which he operated on and reported in 1905, and appending a complete bibliography prepared by the Bibliographic Department of the New York Academy of Medicine.

CASE REPORT

R. R., colored, was brought to the clinic January 5, 1935, when ten months old. His mother had noticed a deformity of the leg at the time of birth. Examination showed a well formed, seemingly normal baby with a deformity of the right leg, which was held in the position of flexion and abduction at the knee with the foot in equino varus of an extreme degree. Both femora were of the same length but there was shortening of 2 inches, measuring from the anterior superior spines to the tip of the external malleolus. The knee could be extended passively to 170 degrees and flexed to 140 degrees; abduction reduced to 15 degrees. The head of the fibula could be palpated posterior to and above its normal position; it lay posterior to the lateral condyle. No trace of a tibia could be found by palpation, either head, crest or internal malleolus. The foot was in inversion of 50 degrees, adduction through vertical axis at the mediotarsal to 45 degrees and there was equinus with plantar flexion of 60 degrees.

On January 10, 1935, anteroposterior (Fig. 1) and lateral views of both lower extremities, from the hip joints to the feet inclusive, showed no bony anomally of either hip, femora, lower left leg and left foot. There was, however, complete congenital absence of the right tibia, with no evidence of primary centers of ossification of the proximal end, of the tibial tuberosity or of the medial malleolus, which are usually visualized during the first month of infancy, and there was no suggestion of fibrosis or calcification in the normal position of the shaft. The fibula was hypertrophied, shorter than normal and straight. The proximal end was displaced posteriorly and the distal end laterally from the astragalus. The right foot, although in a position of extreme equino varus, shows no bony anomalies, although occasionally, with complete absence of the tibia, the mesial elements of the foot are also lacking.

On January 22, 1935, the patient was given a general anesthetic and the foot was manipulated. Much of the deformity could be overcome but the normal positions could not be fully attained. A plaster of Paris cast was applied and was renewed every few weeks, holding the extremity in the best position attainable.

On April 1, 1935, an operation was performed. A vertical incision 2 inches long over the anterior border of the external malleolus exposed the superior articular surface of the astragalus. In the center of this surface a depression was made with a gouge to receive the tip of the malleolus. The malleolus was then denuded of all soft tissue, care being taken not to disturb the periosteum. The tip of the malleolus was then placed in the depression made to receive it and the wound closed. An incision was then made over the lateral condyle, anterior to the lateral ligament. The head of the fibula was exposed and the structures which more or less immobilized it were divided so that it could be manipulated into the intracondylar notch, where it was secured by sutures passing around the bone and then through the structures on the anterior medial side of the femur. The wound was closed and a plaster of Paris cast, extending from the groin to the tips of the toes, applied.

On April 16, 1935, a roentgen examination through a plaster cast showed the external malleolus in contact with the superior articular surface of the astragalus and in good alignment. The proximal end of the fibula, however, was still displaced externally and posteriorly. Films made on September 12, 1935, showed no change

FIG. 1. Case R. R.

in the relative position of the distal end of the fibula, but the proximal end now showed complete lateral displacement.

On January 28, 1936, a long leg brace, with no joints and a high shoe, was applied. Our attempt to retain the upper end of the fibula in the intracondylar notch was unsuccessful, but the operation on the foot seemed to be satisfactory. It was decided to postpone further operation on the knee until the foot had developed and all danger of its deformity recurring had been overcome. The patient was allowed to use his leg as freely as he wished and, being a very active boy, he was on it the greater part of the time.

A roentgen examination made on May 5, 1936, showed considerable growth and development of the fibula with calcification of the epiphysis of the external malleolus, but showed no change in the relative position of the fibula since the previous roentgen examination.

The patient wore the brace continuously until September, 1939, except for a few intervals of several weeks when plaster casts were used in attempts to further alter the proximal end of the fibula. While wearing the brace, adhesive plaster was used to overcome adduction and inversion of the foot. During this period several roentgenograms were taken.

Films made in March, 1937 through a plaster cast showed continued development of the fibula, but the displacement at the knee was still present. It was also noted that at this time the lower fibula epiphysis could no longer be seen.

On December 15, 1937, there was still no change in the position of either end of the fibula, but the lower epiphysis was still absent and the superior articular surface of the astragalus was irregular with postoperative osteoblastic changes taking place, but the lateral displacement had been improved. The proximal end of the fibula now showed the early changes of beginning calcification of the epiphysis, and now for the first time was noticed a small spherical area of calcification in the region normally oc-

cupied by the epiphysis of the proximal end of the tibia, which may represent a very much delayed ossification of this epiphysis, or possibly a multiple patella center of ossification.

On July 18, 1939, the roentgenograms (Figs. 2 and 3) showed continued growth of the fibula, with some calcification of a small and deformed proximal epiphysis. The spherical area of calcification in the region normally occupied by the epiphysis of the proximal end of the tibia, referred to in the previous report, had now very

Fig. 2. Case R. R. July 18, 1939.

much increased in size, and a delayed ossification center for the patella had now appeared in its normal position. The distal end of the fibula still showed no evidence of an epiphysis, but it was in fair alignment and contact with the superior articular surface of the astragalus, which showed evidence of arthritic changes. Films made two months later showed essentially the same roentgen findings.

On September 27, 1939, a second operation on the knee joint was performed. The incision was practically the same as the one used previously. The head and neck of the fibula were denuded of all soft tissues and, using a gouge, a

Fig. 3. Case R. R. July 18, 1939.

depression large enough to receive the head of the fibula was made in the intracondylar notch. The knee was strongly flexed under traction and using the thumb for a fulcrum back of the neck, the head of the fibula, by extension of the

Fig. 4. Case R. R. September 30, 1939.

FIG. 5. Myers' case.

knee, was forced into the prepared cavity. Plaster of Paris was applied.

On September 30, 1939, a postoperative roentgen examination was made through a plaster cast (Fig. 4), and when compared with the previous films, showed the head of the fibula in an improved anatomical relationship and in a depression surgically prepared in the external condyle and intracondylar notch. The distal end of the fibula showed no change in its relative position since the previous report, and the ossification center of the patella and the one in the region of the normal position of the proximal end of the tibia were visualized as slightly increased in size. The identity of this latter ossification center is uncertain, as the possibility of a multiple ossification center for the proximal end of the fibula should also be considered.

For four or five days following the operation of September 27 the patient suffered a great deal of pain, necessitating opiates. Since then he has suffered no pain and is up and about in the plaster cast. It is proposed to replace the cast, in two months, with a brace having joints at the knee and ankle. Meanwhile, each time the cast is replaced the knee is passively flexed. It should be mentioned that, at the last operation, it was deemed wise to do no more dissection than was absolutely necessary, since those who have dissected the amputated legs in these cases have reported gross alterations in the muscular development and the muscular attachments which it would be inadvisable to change, as changing the location and attachment of these structures might result in ultimate weakness of the joint. One of the most striking things noticed by surgeons who have dissected in these cases is the existence of a length of strong, fibrous tissue in the normal location of the tibia. Most of the muscles and blood vessels are abnormally placed. Parona, quoted by Myers, reported that he saw some signs of ossification of such a fibrous band. Several have operated upon these cases with the idea of preserving the leg. Motta made a hollow in the lateral condyle to receive the head of the fibula. Dusche implanted the fibula in a wedge-shaped depression between the condyles. Kincheeal attempted to split the fibula and insert the lower end of the femur into the cleft; but the popliteal artery was injured, due to its anomalous position, and gangrene set in and the patient died.

With the kind assistance of Dr. Frederick J. Matthews, we were able to get in touch with the case reported by Dr. T. H. Myers in 1905. This patient, now a man over thirty-five years of age, came to us for examination. He is married and has four children. It is interesting to note that, of his four children, one has a congenital absence of the middle of the tibia, both ends being present, and another has an absence of three-quarters of the fibula. He is a public accountant and therefore need not be much on his feet, but he likes to walk and to dance, can march in a parade without falling behind, and has no pain when he has a proper shoe. If the shoe does not balance his foot correctly, he gets pressure sores. He limps, but not pronouncedly. As he wears a long leg brace with both bars reaching to the groin, he was asked if he would not be better off had he had the leg amputated and he unhesitatingly and vehemently answered "No." He spoke of several acquaintances, he recalled six at the moment, who have artificial legs, and said that not one of them is as well off as he; one uses crutches most of the time, and all have more trouble with their artificial legs than he has with his brace.

In examining the knee, the movements of the joint were found to be very good. There was present, however, a genu valgus which was not entirely overcome when the leg was in the brace. The foot was in marked equinus and

there was no movement at the ankle joint. There were present a slight inversion and 10 degrees of adduction. The distance from the anterior superior spine was 33½ inches on the left side and 27 inches on the right; but the position of equinus made up for 3 inches of this shortening.

We present roentgenograms of his leg taken at the time of this examination, showing congenital absence of the entire right tibia with no ossification centers present (Fig. 5). The fibula is approximately one-half the length of the normal fibula, but the proximal end has enlarged and approximates the shape of the head of a tibia, but is very much smaller. The patella is apparently well developed, but occupies a high position and approximately one-half inch below its lower border is seen a round area of increased density which may represent a separate center of ossification for the patella. The articular surface of the distal end of the femur is irregular and roughened, but there is considerable interarticular space between the distal end of the femur and the fibula. The distal end of the fibula shows complete bony ankylosis with the astragalus, which in turn is also ankylosed to the superior surface of the os calcis.

This case was reported in the *American Journal of Orthopedic Surgery*, July, 1905. The case and Dr. Myers' handling of it are fully described and a bibliography is given. He cut off the tip of the external malleolus, denuded the superior surface of the astragalus of cartilage and did not attempt to obtain a movable ankle. He placed the upper end of the fibula under the lateral condyle of the femur and used portions of the capsule, attached to the fibula, to retain it in place. Dr. Myers carefully noted the presence of rudimentary patellae, almost round, one-half inch in diameter, lying tandem fashion about one-third inch apart.

CHRONOLOGICAL LIST

No. 1 Reported in 1841 by Otto. One case, No. 257, right in fetus aged six months. Accepted as involvement of right leg by Joachimsthal in 1894 (p. 155) and by Burckhardt (p. 388), but questioned by Ludwig von Muralt (p. 16). Accepted as bilateral by Launois and Küss (p. 331).

No. 2 Reported in 1853 by W. J. Little. One case, shown in figure 135, p. 329; right side; general discussion, pp. 328–332. Listed by Young in 1904 (p. 280).

No. 3 Reported in 1861 by Billroth. One case, No. 1, pp. 252–254, in newborn male. It is not clear whether this case has unilateral or bilateral involvement, as the reference on p. 252 is to the right leg, while the reference on p. 253 is to the left. In the literature the case is consistently reported as involving the right side alone.

No. 4 Reported in 1861 by Förster. One case, total bilateral involvement, accepted as genuine by Launois and Küss (pp. 435 and 438–439) and by Ludwig von Muralt (p. 17).

No. 5 Reported in 1866 by Dornseiff. One case, No. 5, in fetus, pp. 19–20.

No. 6 Reported in 1869 and 1870 by Bauer. One case, right in boy ten years old. Accepted by Burckhardt (pp. 385 and 387) but questioned by Ludwig von Muralt (pp. 11 and 17).

No. 7 Reported in 1877 by Albert. One case, right in girl aged nine months.

No. 8 Reported in 1880 by Albert but contributed by Kleinwächter. One case, No. 2, preserved specimen, left in newborn child, pp. 679–681.

No. 9 Reported first by Wilhelm von Muralt in 1880, then by Burckhardt in 1890, and lastly by Ludwig von Muralt in 1896. One case, left in boy aged eight weeks in September, 1877.

No. 10 Reported in 1882 by Hildemann. One case, left in boy aged twelve years. Accepted as genuine by Gaenslen (p. 457) but listed as partial by Launois and Küss (p. 438). Possibility of rudimentary tibia noted by Joachimsthal in 1894 (p. 161).

No. 11 Reported in 1882 by Parker but contributed by Baker and Read. One case, No. 2, bilateral in boy of two years, pp. 238–239.

No. 12 Reported in 1885 by Reverdin and Laskowsky. One case, No. 10, right in girl aged thirteen years.

No. 13 Reported in 1885 by Erlich. One case, No. 4, bilateral in girl aged eight months, pp. 126–129.

No. 14 Reported in 1886 by Thümmel. One case, right in boy aged three years.

No. 15 Reported in 1886 by Horrocks. One case, right in fetus.

No. 16 Reported in 1886, 1888, and 1892 by Busachi. One case, right in female infant.

No. 17 Reported in 1888 by White and Baker. One case, bilateral in girl four and a half years old.

No. 18 Reported in 1888 by Young. One case, left in boy aged three months.

No. 19 Reported in 1888 by Medini. One case,

left in girl followed up from age of ten months to age of five years.

No. 20 Reported in 1889 by M'Laren but contributed by Watson. One case, amputation specimen, unilateral in boy aged two years.

No. 21 Reported in 1890 by Motta. One case, right in girl aged seven months.

No. 22 Reported in 1891 by Chrystie. One case, right in boy aged two and a half years. Accepted as genuine by Ludwig von Muralt (p. 17) and by Launois and Küss (p. 438).

No. 23 Reported by Sutton in 1892 but contributed by MacLeod and Rope; followed up by Evans and Smith in 1926. One case, left in girl aged eighteen years.

Nos. 24–25 Two cases reported in 1894 by Joachimsthal (one contributed by Wolff, the other by Olshausen). Wolff's case: right in girl aged fourteen months. Olshausen's case: preserved specimen from right leg of boy aged three days.

No. 26 Reported in 1894 by Hoffa. One case, bilateral in child of six months. Quoted by Ludwig von Muralt (p. 17) and by Launois and Küss (p. 438).

No. 27 Reported in 1894 by Rincheval. One case, No. 3, right in child aged seven weeks, pp. 805–809.

No 28 Reported in 1895 by Waitz. One case, bilateral in boy of almost nine months.

No. 29 Reported in 1895 by Kümmel. One case, No. 7, bilateral in girl aged six weeks, p. 13.

Nos. 30–31 Two cases reported in 1896 by Clutton, one of them being reported again in 1926 by Evans and Smith. One case, No. 2, bilateral in girl of eight years. The other, No. 3, right in boy aged seventeen years.

Nos. 32–33 Two cases reported in 1897 by McKenzie (one contributed by Mundell, the other by Addison). Case No. 1, bilateral in boy of eight months (Addison). Case No. 2, bilateral in girl of two years (Mundell).

No. 34 Reported in 1900 and 1901 by Launois and Küss. One case, bilateral, in boy aged three and a half years.

No. 35 Reported in 1900 by Tschmarke. One case, No. 1, right in boy aged four years.

No. 36 Reported in 1900 by Klaussner. One case, No. 8, right in boy aged five years.

No. 37 Reported in 1902 by Helbing. One case, left in boy aged six weeks.

No. 38 Reported in 1902 by Steele. One case, right in girl aged nine and a half months.

No. 39 Reported in 1903 by Nolte. One case, right in boy aged one and a half years.

No. 40 Reported in 1904 by Bötticher. One case, left in a female twin aged two years.

No. 41 Reported in 1904 by Munro but contributed by Baring. One case, right in man of twenty-seven.

No. 42 Reported in 1904 by Young but contributed by Erlich. One case, No. 4, right in girl of fifteen years.

No. 43 Reported in 1905 and 1910 by Myers. One case, right in boy followed up from aged of two years to eight years.

No. 44 Reported in 1905 by Townsend, according to Myers in 1905 (p. 400). One case, "which seemed to be a total defect on one side and partial defect on the other."

No. 45 Reported in 1905 by Blumenthal and Hirsch. One case, right in woman of forty-five.

No. 46 Reported in 1906 by Draudt. One case, bilateral in girl aged one year.

No. 47 Reported in 1907 by Le Fort (observed in collaboration with Vermullen). One case, in male aged two months; side not indicated.

No. 48 Reported in 1908 by Kaehler. One case, right in boy aged twelve years.

No. 49 Reported in 1909 by Baradulin. One case, bilateral in girl aged three years. Tibias totally absent but replaced by fibrous cord.

No. 50 Reported in 1910 by Reichard. One case, right in boy aged fourteen years.

No. 51 Reported in 1912 by Yrázu. One case, right in boy aged four years.

No. 52 Reported in 1912 by Schwarzbach and in 1932 by Aletter. One case, right in boy followed up from age of one and a half years to about twenty-one years.

No. 53 Reported in 1913 by Dunajewsky. One case, right in newborn female dying at age of three months.

No. 54 Reported in 1914 by E. M. Little. One case, bilateral in boy aged three and a half years.

No. 55 Reported in 1915 by Gaenslen. One case, No 1, bilateral in girl aged two years.

No. 56 Reported in 1918 by Davidson. One case, bilateral in boy aged two years.

Nos. 57–58 Reported in 1919–1920 by Bertaux. Case No. 1 (contributed by Launay, pp. 11–18), right in man of twenty-four. Case No. 2 (personal, pp. 18–32), bilateral in man of twenty-three.

Nos. 59–61 Three cases reported in 1920 by Nuzzi.

Case No. 1, bilateral in boy aged four years. Case No. 2, right in boy aged three years. Case No. 3, left in boy aged one year.

No. 62 Reported in 1920 by Elmslie and again in 1926 by Evans and Smith. One case, bilateral in girl aged thirteen years and eight months.

No. 63 Reported in 1922 by Zorraquín. One case, bilateral in man aged about twenty-five years.

No. 64 Reported in 1922 by Vallois and Roume. One case, right in new born male.

No. 65 Reported in 1923 by Desfosses. One case, bilateral in infant. No details.

No. 66 Reported in 1924 by Rodríguez Castro and Escardó Anaya. One case, right in boy aged eight years.

No. 67 Reported in 1924 by Evans and again in 1926 by Evans and Smith. One case, left in boy aged one year and three months.

Nos. 68–70 Reported in 1925 by Ollerenshaw. Cases 1–2, left in female twins (age not given, but around 5 years according to photograph). Case 3, right in full-term male child.

Nos. 71–73 Reported in 1926 by Evans and Smith. Case No. 1 (belonging to Evans and seen in 1915), bilateral in male aged three weeks. Case No. 4 (belonging to Fairbanks and seen in 1924), right in male aged two years. Case No. 6 (belonging to Bryant and seen in 1888), right in infant. [Evans and Smith also follow up four other cases of total absence and one of partial absence of the tibia: case No. 2 (Evans, 1923); case No. 3 (Elmslie, 1920); case No. 5 (Cautley, 1915, but partial); case No. 7 (Clutton, 1896); and case No. 8 (Sutton, 1892).]

No. 74 Reported in 1926 by Overhof. Impossible to verify.

No. 75 Reported in 1927 by Schwartz. One case, left in girl of three and a half years.

Nos. 76–77 Reported in 1928 by Del Torto. Two cases, No. 1 right in girl aged three months, and No. 2 right in boy aged three months.

No. 78 Reported in 1929 by Legal. One case, right in man of twenty-one.

Nos. 79–81 Reported in 1929 by Putti. Three incomplete case reports. No. 1 in male (fig. 11 a and b), No. 2 (fig. 12 a–d), and No. 3 in male (figs. 13 a–e and 14 a–c).

Nos. 82–83 Reported in 1931 by Carraro. Two cases, No. 2 right in girl aged eight years, and No. 3 in right leg of boy aged four years.

No. 84 Reported in 1932 by Gutiérrez Guijarro, *et al.* One case, right in girl aged two years.

No. 85 Reported in 1934 by Alcalde Noy and Martínez Fraile. One case, right in girl five days old.

No. 86 Reported in 1935 by López Fernández. One case, right in boy aged seven months.

No. 87 Reported in 1936 by Dietrich, *et al.* One case, right in boy aged eight years.

No. 88 Reported in 1936 by de Araújo. One case, bilateral (just mentioned on p. 236).

No. 89 Reported in 1936 by Pujol-Ségalas. One case, unilateral in girl aged eleven years (side involved not indicated).

REFERENCES

1841–1936

Albert, E. Beiträge zur operativen Chirurgie. III. Implantation der Fibula in die Fossa intercondyloidea femoris bei angeborenem Defekt der ganzen Tibia. *Wien. med. Presse*, 1877, *18*, 111–113.

Albert, E. Zwei seltene Fälle von angeborenen Missbildungen an den Gliedmassen. *Wien. med. Bl.*, 1880, *3*, 305; 679.

Alcalde Noy, L., and Martínez Fraile, T. Hemimelia del esqueleto de la pierna derecha; ausencia completa congénita, de la tibia y rótula derechas. *An. de pediat.*, 1934, *1*, 717–723.

Aletter, C. Über die angeborenen Defekte der Tibia. *Frankfurt. Ztschr. f. Path.*, 1932, *43*, 196–221. [Long bibliography.]

de Araújo, A. Tratamento cirurgico da ausencia congenita da tibia. *Arq. brasil. de cir. e ortop.*, 1936, *4*, 235–240.

Baradulin, I. I. [Congenital absence of the tibia.] Russian text in: *Russk. chir. arch.*, 1909, *25*, 829–835. German summary on p. 14 of the Dunajewsky thesis, which see.

Bauer, L. Angeborener Defecte der unteren Extremitäten. . . . *Arch. f. klin. Chir.*, 1869, *10*, 743–747. Abst. in his textbook "Handbuch der orthopädischen Chirurgie," A. Hirschwald, Berlin, 1870, pp. 70–73.

Bertaux, M.-A. Contribution à l'étude de l'absence congénitale du tibia. Paris thesis. 1919–1920.

Billroth, T. Ueber einige durch Knochendefecte bedingte Verkrümmungen des Fusses. *Arch. f. klin. Chir.*, 1861, *1*, 251–258.

Bland Sutton. See: Sutton, J. B.

Blumenthal, M., and Hirsch, K. Ein Fall angeborener Missbildung der vier Extremitäten. *Ztschr. f. orthop. Chir.*, 1905, *14*, 11–33.

Böttticher. Angeborener totaler Defekt der linken Tibia. *Deutsche med. Wchnschr.*, 1904, *30*, 1594.

Burckhardt, L. Beiträge zur Diagnostik und Ther-

apie der congenitalen Knochendefecte an Vorderarm und Unterschenkel. *Jahrb. f. Kinderh.*, 1890, *31*, 375–427.

BUSACHI, T. Casi rari di affezioni congenite . . . 6. Un caso di mancanza congenita della tibia, con speciale riguardo alla sua cura. *Arch. di ortop.*, 1892, *9*, 100–113. (Just bibliography for case reported in 1886.)

BUSACHI, T. Un caso di mancanza congenita della tibia, con speciale riguardo alla sua cura. *Gior. d. r. Accad. di med. di Torino*, 1886, *34*, 763–771. Abst. in: *Arch di ortop.*, 1888, *5*, 105–108.

CARRARO, A. Assenza congenita della tibia e sordomutismo in quattro fratelli. *Chir. d. org. di movimento*, 1931, *16*, 429–438.

CHRYSTIE, T. M. L. Congenital club-foot with absence of the great toe and the contiguous bones of the instep. *Tr. Am. Orthop. Ass.*, 1891, *4*, 32–37. Also: *M. News*, 1891, *59*, 510–511.

CLUTTON, H. H. The surgery of deformities. Chap. 35 in: A System of Surgery (ed. by Treves), 1896, *2*, 38–91. (Fig. 529, p. 88 and discussion on p. 90; boy of 17 years.)

CLUTTON, H. H. Three specimens of absent tibiae. *Tr. Clin. Soc. Lond.*, 1896, *29*, 223–226. (Case 2, in girl of 8 years, also reported on pp. 203–204 of Evans and Smith in 1926. Case 3, boy of 17 years, same as case in previous reference.)

DAVIDSON, A. J. A case of congenital deformity of the hands, supernumerary toes, and absence of tibiae. AM. J. ROENTGENOL., 1918, *5*, 434–436.

DEL TORTO, P. Alcuni casi di assenza congenita della tibia e del perone. *Pediatria*, 1928, *3*, 219–242.

DESFOSSES, P. Absence de développement du tibia et du péroné. *Presse méd.*, 1923, *31*, 2078.

DIETRICH, LASSERRE, C., and SAFT. Absence congénitale du tibia. *J. de méd. de Bordeaux*, 1936, *113*, 501.

DORNSEIFF, O. Zur Aetiologie der congenitalen Luxationen des Hand- und Fussgelenkes. Giessen thesis. 1866.

DRAUDT. Ein seltener Fall von Extremitäten-Missbildung. *Verhandl. d. deutsch. Gesellsch. f. Chir.*, 1906, *35*, 203–205.

DUNAJEWSKY, I.-B. Angeborener Tibiadefekt. Munich thesis. 1913.

ELMSLIE, R. C. Congenital absence of the tibiae. *Proc. Roy. Soc. Med.* (*Sect. Orth.*) 1920, *13*, 224–225.

ERLICH, N. Untersuchungen über die congenitalen Defecte und Hemmungsbildungen der Extremitäten. *Arch. f. path. Anat.*, 1885, *100*, 107–138.

EVANS, E. L. Case of left unilateral complete absence of the tibia. *Proc. Roy. Soc. Med.* (*Sect. Orth.*), 1924, *17*, 53–54.

EVANS, E. L., and SMITH, N. R. Congenital absence of tibia. *Arch. Dis. Childhood*, 1926, *1*, 194–229.

FÖRSTER, A. Die Missbildungen des Menschen systematisch dargestellt. F. Mauke, Jena, 1861.

GAENSLEN, F. J. Congenital defects of the tibia and fibula. *Am. J. Orthop. Surg.*, 1915, *12*, 453–481. [Bibliography.]

GUTIÉRREZ GUIJARRO, M., LÓPEZ FERNÁNDEZ, A., and MORÁN CIFUENTES, B. Ausencia congénita total de tibia. *Arch. de med., cir. y espec.*, 1932, *35*, 666–669.

HELBING, C. Ein Fall von totalem Defect der Tibia. *Berl. klin. Wchnschr.*, 1902, *39*, 316. Also: *Verhandl. d. Berl. med. Gesellsch.*, 1902, *33:* part I, 120, 1903. Abst. in: *Ztschr. f. orthop. Chir.*, 1903, *11*, 641.

HILDEMANN, A. Beitrag zur Causuistik der angeborenen Hemmungsbildungen der Extremitäten. Kiel thesis. 1882.

HOFFA, A. Ueber Defectbildung an den unteren Extremitäten. *Verhandl. d. physikalisch-med. Gesellsch. in Würzburg*, 1894, *28*, 96. (Impossible to verify.)

HORROCKS. Malformed foetus. *Tr. Obst. Soc. Lond.*, 1885, 1886, *27*, 131–134.

JOACHIMSTHAL, G. Ueber den angeborenen totalen Defect des Schienbeins. (Nach einem am 8. Januar 1894 in der Freien Vereinigung der Chirurgen Berlins gehaltenen Vortrage.) *Ztschr. f. orthop. Chir.*, 1894, *3*, 140–173.

JOACHIMSTHAL, G. Ueber den congenitalen Defect der Tibia. Bemerkungen zu der Mittheilung des Herrn Dr. H. Waitz in Nr. 25 dieser Wochenschrift. *Deutsche med. Wchnschr.*, 1895, *21*, 437.

KAEHLER. Totaler und partieller Tibiadefekt. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1908, *12*, 179–181.

KLAUSSNER, F. Über Missbildungen der menschlichen Gliedmassen und ihre Entstehungsweise. J. F. Bergmann, Wiesbaden, 1900.

KÜMMEL, W. Die Missbildungen der Extremitaeten durch Defekt, Verwachsung und Ueberzahl. Bibliotheca medica, Abth. E, Chir., Heft 3. Cassel: T. G. Fisher. 1895. (P. 13 and chart in table III A.)

LAUNOIS. Présentation d'un enfant offrant une absence congénitale des deux tibias. *Gaz. d. hôp.*, 1900, *73*, 1030. (Abst. of paper by Launois and Küss read at Internat. Congress in 1900.)

LAUNOIS, P. E., and KÜSS, G. E. Absence congénitale double du tibia. Abst. in: *XIII^e Cong. internat. de méd., Paris*, 1900, *5: Section de Chirurgie de l'Enfance, compt. rend.*, p. 225, 1900. Disc., p. 226.

LAUNOIS, P.-E., and KÜSS, G. Étude sur l'absence congénitale du tibia. Full paper in: *Rev. d'orthop.*, 1901, *2*, 327–348; 411–439.

LE FORT, R. Absence congénitale de tibia. *Écho méd. du nord*, 1907, *11*, 55–56.

LEGAL, W. Ein Fall von angeborenen totalen Tibiadefekt mit weitgehender Deformierung des Fusses. *Ztschr. f. orthop. Chir.*, 1929, *52*, 464–468.

LITTLE, E. M. Case of congenital absence of tibiae. *Proc. Roy. Soc. Med.* (*Sect. Orth.*), 1914, *7*, 161–162.

LITTLE, W. J. On the nature and treatment of the

deformities of the human frame . . . Longman, Brown, Green, and Longmans, London, 1853. (Fig. 135, p. 329, and pp. 328–332.)

López Fernández, A. Ausencia congénita total de tibia. *Crón. méd.*, 1935, *39*, 476–480.

McKenzie, B. E. Congenital defects of the long bones. *New York M. J.*, 1897, *65*, 241–248.

M'Laren, J. S. A case of congenital absence of the tibia. *J. Anat. & Physiol.*, 1889, *3*, 598–605.

Medini, L. Un caso di mancanza congenita della tibia. *Bull. d. sc. med.*, 1888, *22*, 145–150.

Motta, M. Un caso di mancanza congenita della tibia. *Arch. di ortop.*, 1890, *7*, 304–311.

Munro, H. L. A case of congenital absence of one tibia. *Lancet*, 1904, *2*, 526–527.

v. Muralt, Ludwig. Ueber congenitalen Defekt der Tibia mit anatomischer Untersuchung eines Falles von totalem congenitalem Tibiadefekt. Bibliotheca medica, Abth. C, no. 5. Cassel: T. G. Fisher. 1896. (Follow-up of case originally reported by Wilhelm von Muralt in 1880 and later by Burckhardt in 1890.)

v. Muralt, Wilhelm. 2 seltene Fälle von Missbildung der Unterextremität. (1) Totaler angeborener Mangel der Tibia. German text in: *Correspondenz-Blatt f. schweiz. Aertze*, 1880, *10*, 724–725. French abst. in: *Rev. d. sc. méd.*, 1883, *21*, 451–452. (Original report of case followed up by Ludwig von Muralt in 1896 and by Burckhardt in 1890.)

Myers, T. H. Congenital absence of tibia: transplantation of head of fibula: arthrodesis at the ankle-joint. *Am. J. Orthop. Surg.*, 1905, *3*, 72–85. (See 1910 report for follow-up.)

Myers, T. H. Further report on a case of congenital absence of the tibia. *Am. J. Orthop. Surg.*, 1910, *8*, 398–400. (See original report in 1905.)

Nolte, A. Ein Fall von congenitalem totalen Tibiadefekt. Leipzig thesis. 1903. Abstract on p. 13 of the Dunajewsky thesis, which see.

Nuzzi, O. L'assenza congenita della tibia e le deformità relative. *Chir. d. org. di movimento*, 1920, *4*, 164–196.

Ollerenshaw, R. Congenital defects of the long bones of the lower limb. A contribution to the study of their causes, effects, and treatment. *J. Bone & Joint Surg.*, 1925, *7*, 528–552.

Otto, A. W. Monstrorum sexcentorum descriptio anatomica. Sumptibus Ferdinandi Hirt, Breslau, 1841. (Case 257, pp. 149–150 and table 17, figs. 5–8.)

Overhof, K. Ein Beitrag zur Frage der angeborenen Missbildungen am Unterschenkel (Totaler, doppelseitiger Tibiadefekt.) Heidelberg thesis. 1926. [1928]. (Impossible to verify.)

Parker, R. W. Congenital absence of long bones. (Living cases.) *Tr. Path. Soc. Lond.*, 1881–1882, 1882, *33*, 236–239. Abst. in: *Lancet*, 1882, *1*, 870.

Pujol-Ségalas, E. L'absence congénitale du tibia et les difformités consécutives. Paris thesis. 1936.

Putti, V. Cura dell'assenza congenita della tibia e del perone. *Chir. d. org. di movimento*, 1929, *13*, 513–525.

Reichard. Demonstration. Angeborener Totaldefekt der rechten Tibia. *München. med. Wchnschr.*, 1910, *57*, 2663.

Reverdin, J.-L., and Laskowsky. Observations cliniques. No. 10. Malformation congénitale de la jambe droite. Amputation. *Rev. méd. de la Suisse Rom.*, 1885, *5*, 592–602.

Rincheval. Ein neues Operationsverfahren zur Behandlung congenitaler Defecte eines Unterarm- und Unterschenkelknochens. *Arch. f. klin. Chir.*, 1894, *48*, 802–810.

Rodríguez Castro, A., and Escardó Anaya, V. Un caso de ausencia congénita de ambas tibias. *An. de la Fac. de med.*, 1924, *9*, 148–156. French Abst. in: *Presse méd.*, 1924, *32*, 1419.

Schwartz, E. Kongenitaler Defekt der Tibia. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, *36*, 673–674.

Schwarzbach, W. Ueber angeborenen Defekt der Tibia und Ulna. *Zentralbl. f. Chir. u. mech. Orthop.* 1912, *6*, 345–370. (Original report of case followed up by Aletter in 1932.)

Steele, A. J. Congenital absence of the tibia. *Tr. Am. Orth. Ass.*, 1902, *15*, 74–76.

Sutton, J. B. Congenital absence of the tibia. (Card specimen) *Tr. Path. Soc. Lond.*, 1891–1892, 1892, *43*, 124–126. (Follow-up by Evans and Smith in 1926.)

Thümmel, H. L. Ein Fall von congenitalem Defekt der ganzen Tibia. Halle thesis. 1886.

Townsend. Quoted on p. 400 of 1905 article by Myers.

Tschmarke, P. Zwei seltene Formen angeborener Missbildung. *Ztschr. f. orthop. Chir.*, 1900, *8*, 368–378.

Vallois and Roume. Malformation du membre inférieur chez un nouveau-né. Absence congénitale du tibia et présentation de radiographie et de l'enfant. *Bull. Soc. d'obst. et de gynéc. de Paris*, 1922, *11*, 535–537.

Waitz, H. Ueber einen Fall von congenitalem Defect beider Tibien. *Deutsche med. Wchnschr.*, 1895, *21*, 405–406.

White, W. H., and Baker, H. Case of congenital deformity of femora, absence of tibiae, and malformation of the feet and hands. *Tr. Clin. Soc. Lond.*, 1888, *21*, 295–297.

Young, J. K. Double congenital deformity of the tibia. *Am. J. M. Sc.*, 1888, *95*, 145–150.

Young, J. K. The etiology of congenital absence of the tibia. *Univ. Pa. M. Bull.*, 1904, *17*, 274–287.

Yrázu, E. Ausencia congénita de la tibia. Buenos Aires thesis. 1912.

Zorraquín, G. Ausencia congénita de ambas tibias. Utilización del muñón. *Semana méd.*, 1922, *2*, 988–990.

THE TREATMENT OF MALIGNANT TUMORS OF THE TESTIS

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PRACTICALLY all tumors of the testis are malignant. Many of them metastasize early and, although the primary tumor is easily removed, the prognosis, by any method of treatment, is poor. The purpose of this paper is to present the data obtained from a review of our patients, and from this, attempt to outline an optimum therapeutic plan.

Malignant testicular tumors are not common. Between December, 1916, and December, 1938, a period of twenty-two years, 45 patients with tumor of the testis have been seen in the Department of Radiology at the Hospital of the University of Pennsylvania. During this same period approximately 4,400 cases of malignant diseases of all varieties have been studied. Testicular tumors therefore comprise approximately 1 per cent of all malignant conditions as seen in this department. Hinman[10] gives the incidence as 0.58 per cent of all malignant tumors in the male or about 1 in every 1,500 male surgical admissions to the hospital. Dean[4] found an incidence of 1.008 per cent of all cases of malignant disease.

The age at which our patients were affected is shown in Chart 1. The youngest patient in this series was eighteen years of age, the oldest seventy-four. Thirty-two of our 45 patients were between the ages of twenty and forty. Fifteen were in the third decade and 17 in the fourth decade. These observations conform with those of other writers. Bailey[1] found the greatest number of patients between thirty and forty years of age. Higgins and Buchert[8] gave the average age of their patients as twenty to fifty years. Cabot and Berkson,[3] in reviewing a group of 363 patients, found the average to be 36.2 years.

TABLE I

RESULT OF HISTOLOGICAL STUDY OF 41 TESTICULAR TUMORS

Pathological Type	Number
Teratoma	17
Sarcoma	11
Embryoma	6
Seminoma	3
Mixed tumor	2
Carcinoma	2

Except 4, all of our patients had histological proof of the nature of the malignant condition involving the testicle. One of the 4 exceptions was not operated upon because of hopeless metastasis to the abdomen and chest. This patient subsequently died. Another patient had been operated upon elsewhere ten years before and no pathological report was available. This patient also died of metastasis. The third patient had a tumor the size of an orange which practically disappeared under roentgen therapy but the specimen removed at operation was lost. In the fourth patient, a radiosensitive tumor disappeared leaving only "shadow cells" but no definite malignant disease. These 4 cases were included in fairness to the statistics because they exhibited the characteristics of malignant tumors even though they were not proved histologically (Table 1).

For the purpose of therapeutic procedure it is only necessary to divide these tumors into two types, the radiosensitive and the radioresistant. It is not possible to exactly correlate the radiotherapeutic response with the histopathological type of tumor in every instance but a working classification may be obtained from Table II.

Tumors of the testicle are similar to some other malignant lesions in their insidious onset. The symptoms of the primary tumor are most frequently a painless swell-

ing. This swelling may be noticed accidentally or the patient may receive trauma which attracts his attention to the enlargement. Five of our patients gave trauma as the first sign. Another patient thought his swelling started after sitting on a cold stone. Four of our patients had testicular tumors undiscovered until they came to the hospital for other reasons. Two of these came for repair of a hernia, one for appendicitis, one for abdominal pain from metastasis. In one patient the first evidence was painful, tender breasts. Table III shows the nature and the incidence of the symptoms relative to the primary tumor.

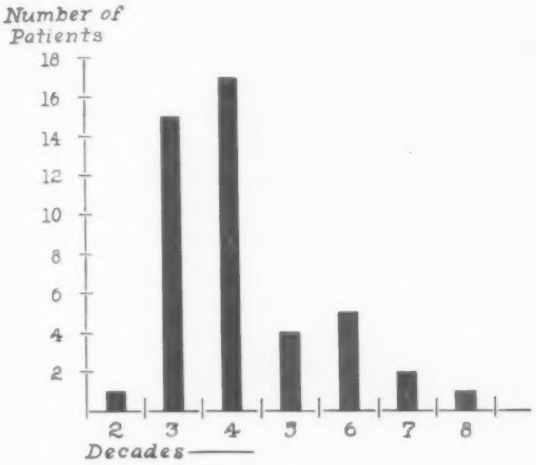

Chart I. The age incidence of 45 patients with tumor of the testis.

Symptoms referable to metastasis are unfortunately a late manifestation. Gastrointestinal disturbances of varying severity may indicate metastasis to the pre-aortic lymph nodes. In a patient with testicular tumor, anorexia, vomiting, distention or pressure sensation in the abdomen indicates the need of a very careful clinical and roentgenologic study for metastasis. Constipation or diarrhea occurring with abdominal metastasis has been an infrequent complaint in our patients. Backache is significant. It may denote beginning obstruction to the ureter. This pain may not be severe and it may subside entirely when the ureteral block has become complete and the involved kidney is no longer functioning. Severe pain in the back usually indicates extensive metastasis to the regional lymph nodes along the aorta and is frequently a late symptom. In only one of our patients was this pain associated with a bone metastasis. Cough, dyspnea, dysphagia or enlarged supraclavicular lymph nodes occur late and usually indicate metastasis above the diaphragm. Hypertrophy of the breast is a peculiar sign which may occur before or after removal of the tumor. It may be unilateral or bilateral. Heidrich, Fells and Mathias[7] report an instance in which both breasts were enlarged to the size of adult fists. There were secretion from the nipples and an increase in the pigmentation about the areola. Entwisle and Hepp[6] have reported one patient in whom gynecomastia was associated with large, clear, swollen chromophobe cells in the pituitary gland such as those which are seen in pregnancy. Five of our patients had swelling of the breast. In one instance, tissue was removed for histological examination and the findings were interpreted as chronic inflammatory tissue. In one of our patients, enlargement of the breast developed one year after removal of a testicular tumor. The clinical and laboratory ex-

Table II

I. Radiosensitive	A. Embryonal tumors	
		1. Chorionepithelioma
		2. Embryonal carcinoma
		3. Sarcoma
		4. Seminoma
II. Radioresistant	A. Adult teratoma	
	B. Dermoid	

Table III

Symptoms Related to the Primary Tumor	Number of Cases
No symptoms; lesion discovered accidentally or on physical examination	4
Symptoms first noted after trauma	5
Pain and swelling of testicle	4
Painless swelling of testicle	32

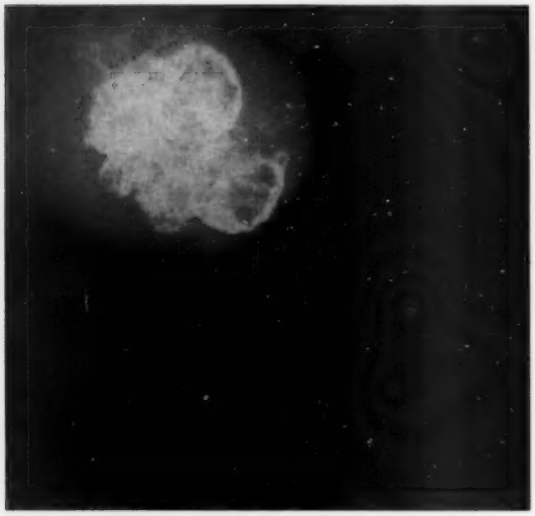

Fig. 1. Calcification in an adult type of tumor of the testis. Such calcification may occur in the primary tumor and in the metastatic lesions in the abdomen.

aminations failed to show any evidence of metastasis and the patient was otherwise in good health. One roentgen therapy exposure of 500 r was given to the breast and the swelling subsided. One month later the left breast became swollen and the swelling subsided following a similar roentgen treatment. This patient is still living without evidence of disease five years later.

The preoperative diagnosis of malignant tumor of the testis may be made by the history, physical examination, hormone tests, roentgenographic examination and therapeutic trial of irradiation.

Frequently the history is not characteristic because of the obscurity of the symptoms. However, a progressive enlargement may denote tumor whereas a recurring swelling may indicate an inflammatory process. The finding of a hard, smooth, nodular, ovoid growth involving one testicle and not the epididymis, with or without enlargement of the cord, is suggestive of a malignant tumor. If both testicles are involved, one should suspect a metastatic growth, since bilateral teratoma of the testis is not common. None of our patients exhibited bilateral tumors.

Confusion in diagnosis is more apt to occur if hydrocele is present together with the tumor. Transillumination and repeated aspiration of fluid may be necessary before a tumor can be diagnosed, although in most cases "needling" is to be avoided whenever a tumor is suspected. The apparent retraction of the penis, which occurs with hydrocele, is usually not seen with tumor. The non-translucent testicular swellings are difficult to diagnose even by the most experienced observers. Hematocele, gumma, tuberculosis and chronic epididymitis may be confused with malignant disease. Calcification seen on the roentgenogram is sometimes significant. It may indicate an adult type of teratoma or a dermoid, as in Figure 1, but it does not exclude an inflammatory lesion such as tuberculosis, particularly if the calcification is smaller than that seen in this illustrations.

Excretory urography is a valuable procedure in the early diagnosis of abdominal metastasis. The anatomical position of the lymphatics which drain the testicle is such

Fig. 2. Intravenous urogram made on April 24, 1939, of a patient with a tumor of the left testis. Note that the left kidney is slightly lower than the one on the right side. No abnormal masses could be palpated in the abdomen.

that the earliest evidences of extension of the disease may be the displacement of the ureter or kidney or evidence of interference with the function of the urinary tract. If, at the time of the first study, the findings indicate a normal urinary tract, this urogram should be kept on file for comparison with future studies.

Two of our patients illustrate the advantages of excretory urograms for the detection of abdominal metastasis before they can be found by any other method.

One of these patients complained of slight pains in the left loin at his first visit to the hospital. Before any treatment was given an intravenous urogram showed what were considered to be normal findings (Fig. 2). The pain disappeared shortly after the preoperative course of roentgen therapy was completed. Five months later this patient returned for follow-up examination. No abdominal masses could be detected by physical examination but the intravenous urogram made at this time showed that the left kidney was displaced downward about 1 inch lower than on the previous roentgenogram (Fig. 3). In retrospect, it is probable that this patient had metastases resulting in some displacement of the left kidney at the time of his first visit, but it was not until a comparative study was done five months later that the metastasis was finally discovered.

FIG. 3. Intravenous urogram of the same patient as Figure 2, made on September 12, 1939. Note the relation of the left kidney to the left twelfth rib and compare its position with that in Figure 2. The left kidney is displaced downward and slightly lateralward by a growing metastatic tumor above the renal pedicle. This patient did not have a palpable tumor in the abdomen at this time.

FIG. 4. Intravenous urogram in a patient with a malignant tumor of the left testicle. There were no abdominal signs or symptoms. Note that both kidneys function satisfactorily. The left kidney shows a slight lateral displacement.

Another patient was first seen in March, 1938, with a painless swelling of the left testicle but no clinical symptoms or signs which might suggest abdominal metastases. An excretory urogram showed a slight lateral displacement of the left kidney which, at the time, was not considered as abnormal (Fig. 4). One year later an abdominal mass could be definitely palpated and the urogram at this time showed no function of the left kidney (Fig. 5). This patient was given radiation therapy over the left abdomen and there has subsequently been a return of the function of the left urinary tract.

Fig. 5. Intravenous urogram of the same patient as Figure 4 one year later. Note the absence of function of the left kidney. At this time a left abdominal mass was palpated.

The expectations of urinary prolan studies in the diagnosis and prognosis of tumor of the testis have not been sustained over the years. Whereas a high figure for prolan in the urine in an untreated individual may indicate a rapidly growing embryonal type of tumor, it may be an unreliable sign after treatment. Two patients in our group in whom the prolan studies were made at intervals following irradiation showed a sudden rise of urinary prolan to 400 and 500 mouse units respectively without any detectable reason. Their subsequent prolan studies were less than 100 mouse units and they have remained clinically free of disease.

A low excretion of urinary prolan should not be allowed to influence the clinical diagnosis or prognosis. MacKenzie and Ratner[13] found only small quantities of hormone in patients with known metastasis. Owen, Polanco and Prince,[14] in a study of 44 cases of teratoma, found a range from negative to 1,000 mouse units of prolan per liter.

Table IV

URINARY PROLAN EXCRETION (FERGUSON TECHNIQUE) PATIENTS CLINICALLY FREE OF METASTASIS*

Histological Type of Tumor	Prolan (Mouse Units)	Result
Embryoma	2000	Living and well
Embryoma	250	Living and well
Embryoma	50	Died in 8 months
Seminoma	100	Living and well
Teratoma	100	Living and well
Teratoma	100	Living and well
Teratoma	250	Died in 1½ years
Teratoma	50	Living and well
Hematocele	100	Living and well
Hematocele	50	Living and well
Chronic epididymitis	50	Living and well

* All urine specimens were voided before any treatment was given.

Table V

URINARY PROLAN EXCRETION (FERGUSON TECHNIQUE) PATIENTS WITH METASTASIS*

Histological Type	Prolan (Mouse Units)	Result
Unknown	5000	Dead
Teratoma	50	Dead
Teratoma	50	Dead
Seminoma	50	Living and well
Embryoma	500	Dead

* All urine specimens were voided before any treatment was given.

Table IV shows the results of the prolan studies in 8 patients with malignant testicular tumors but without clinical evidence of metastasis. Of these, only one had an excretion greater than 250 mouse units per liter. One patient, who had a highly radiosensitive rapidly growing tumor, excreted 50 mouse units per liter. This patient was dead within eight months of his first study. The 3 patients who were treated for malignant testicular tumors, but who subsequently were proved to have a benign condition, are included in the table to show that the prolan studies did not aid in their diagnosis. Table V shows the results in 5 patients who first presented themselves

with definite evidence of metastases to the abdomen. Three of the 5 had prolan excretion figures of 50 mouse units per liter. From these data it seems advisable to conclude that high prolan figures probably indicate embryonal tumors of the testis but low figures do not exclude an embryonal tumor or even a malignant tumor with metastases. It should also be noted that a diminution in the prolan excretion following irradiation is not a reliable prognostic sign since the more radioresistant cells of a mixed type of tumor may metastasize and continue growing after the destruction of the radiosensitive portion of the tumor.

The last of the diagnostic procedures to be applied, and sometimes the most valuable, is the response of the tumor to roentgen therapy. Most of these tumors will show a prompt diminution in size following the administration of a suitable amount of radiation. When this does not occur, the possibility of an adult type of teratoma or a benign condition must be considered. In 5 patients treated preoperatively for suspected tumor of the testicle, no regression was noted. Two of these proved to have an adult type of teratoma, 2 had hematocele and one had a chronic epididymitis. The latter 3 patients are not included in the statistics but are mentioned to show the diagnostic value of irradiation.

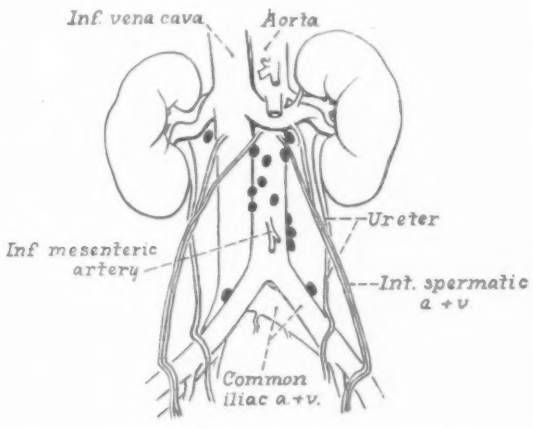

Fig. 6. Diagram showing the distribution of the primary retroperitoneal lymph nodes draining the testes. Note that some of those from the right testicle lie to the left of the vena cava in a position which could block the left renal pedicle or the left ureter. Those glands draining the left testicle all lie along the left side of the aorta.

Fig. 7. Metastatic malignancy involving the mediastinum from primary testicular tumor. Note the widened mediastinum with the frayed edges. The density in the left apex is due to an old tuberculous calcification.

Figure 6 shows the areas which must be covered by the radiation therapy. Jameison and Dobson[12] demonstrated that the primary glands lie in front of and by the sides of the aorta and vena cava, below the level of the renal veins. Each testicle has its own set of primary glands which communicate with each other. On the left side there is a group of glands about the inferior mesenteric artery. Other primary glands occur as high as the left renal artery and as low as the angle between the aorta and the left common iliac artery. On the right side, one to three glands lie in the groove between the vena cava and the aorta. Others occur higher up between the left renal vein and the inferior mesenteric artery. This explains how metastasis from a right testicular tumor can produce an autonephrectomy on the left side. One gland may occur to the right of the inferior vena cava in the angle between the

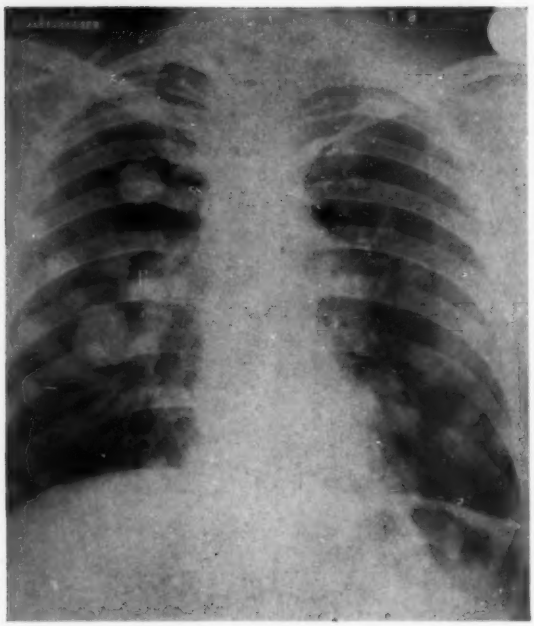

FIG. 8. Hematogenous metastases from tumor of the the testis. The homogeneous round densities have a smooth periphery.

vena cava and the right renal vein. The secondary lymphatics from these primary nodes on the two sides may communicate with each other or they may communicate with lymph nodes in the thorax or in the iliac region.

Metastatic involvement of the thorax may occur as a result of lymphatic extension through the diaphragm into the pulmonary hilum from the retroperitoneal lymph nodes; or it may be blood borne directly from the primary tumor or from the secondary deposits in the abdomen by way of the thoracic duct or directly through the blood stream. The roentgen appearance of the metastatic lesion in the hilum is not characteristic. Enlarged lymph nodes can be demonstrated and the hilum shadow is widened with irregular frayed or stringy shadows extending toward the lung periphery (Fig. 7). The pulmonary metastases, from blood stream dissemination, are characteristic of sarcoma or similar types of tumor such as hypernephroma. They are frequently demonstrable as multiple circular shadows, homogeneous in density and having a smooth periphery. The lesions vary in size and are usually scattered throughout both lung fields (Fig. 8).

Smith, Dresser and Mintz[17] found that 31 per cent of their 100 cases had metastases before treatment was started. More than 50 per cent of the patients studied by MacKenzie and Ratner[13] had metastases when first examined. If one could add to such figures the instances of non-demonstrable metastatic lesions, the incidence becomes still higher. In the series of cases reported by Dean[4] 67 per cent had metastases three months after the first symptoms. In the series presented herein 37.7 per cent of the patients had demonstrable metastases when first seen for treatment.

The treatment of testicular tumors, therefore, becomes the treatment of the metastatic lesions. This observation was made by Tanner[18] who found that in a group of 465 cases with tumor testis, nearly all of whom were treated by orchidectomy, only 25, or 5.5 per cent, survived. Hinman[9] reported 258 patients treated by orchidectomy in which the five year survival was 6 per cent. The latter author has therefore advised the use of radical removal of the pre-aortic lymph nodes in those cases in which the prolan does not return to normal following simple orchidectomy, if there is no clinical evidence of metastasis and when the pathologist reports a mixed type of tumor. Dean,[4] in a well studied series of 154 patients treated by orchidectomy and irradiation, found 29.2 per cent of these patients alive without evidence of disease five or more years. Higgins and Buchert,[8] having studied 81 patients, found that 24 per cent survived five years following orchidectomy, whereas 35.5 per cent lived five years when treated by orchidectomy and irradiation. Desjardins, Counseller and Gianturco[5] found that 48 per cent of 125 patients treated by roentgen therapy after orchidectomy for teratoma survived five years. A recent report by Cabot and Berkson[3] would indicate that irradiation improves the five and ten year survival rate in patients with metastases

but does not alter these same survival rates in the patients with no clinical evidence of metastases.

While there is still considerable argument regarding the choice of therapeutic procedures, most observers seem to agree that surgery alone will cure only a small number of patients and that irradiation, properly carried out, will materially extend the life expectancy of many patients by controlling and sometimes curing the metastatic deposits. Some weight is added to this by the report of Brunschwig and Fox.[2] Their patient was treated for metastases in the chest and abdomen from a seminoma of the testicle. The patient died of a ruptured gangrenous colon and at necropsy no viable tumor cells could be found. Such a response indicates a highly sensitive tumor. At the other extreme of radiosensitivity are the adult teratomas. There is no evidence that these tumors, which constitute about 10 per cent of the entire group, will be benefited by irradiation. It is in this group that Hinman[11] advises the radical operation if the patient is seen before clinical evidence of metastasis has occurred.

Since 1932, we have treated cases of suspected teratoma of the testis by preoperative irradiation, followed in five to six weeks by orchidectomy. This was originally done on the advice of Randall and Bothe[16] and of Pendergrass[15] who have suggested the following thoughts as a rational basis for preoperative irradiation: (1) surgery may be responsible for the dissemination of metastatic seeds; (2) if irradiation before orchidectomy is the treatment of choice for existing metastases it seems logical to use it in the same way when metastatic involvement has not yet become apparent; (3) if there is any value in attempting to seal off lymphatics against the spread of cancer this method should help in obtaining such an alteration; (4) if immunity to cancer can be achieved by the host it is within the realm of probability that early removal may be antagonistic to the best end-results. At the present time this last statement seems highly theoretical.

Prior to 1932 our patients were treated after operation except in one instance where no operation was performed because of the hopeless prognosis. What are the arguments in favor of orchidectomy followed by irradiation? Such a procedure would establish the diagnosis, indicate the radiosensitivity of the tumor, and remove the growth, preventing any further dissemination. To such arguments we have no adequate response except the statistical results in our series and the clinical impressions obtained from our observations of these patients.

For the purpose of this study, our patients were divided into three groups as follows: (1) those patients, without a demonstrable metastasis when first seen, who were treated preoperatively; (2) those patients with no demonstrable metastasis when first seen and in whom the irradiation was given after orchidectomy; (3) those patients with metastases when first observed by us, either before or after orchidectomy.

The method which we have used in giving preoperative irradiation is, briefly, the delivery of about 800 to 1,600 r to the cervical, thoracic and abdominal lymphatics which drain the testes. An average treatment is indicated by Figure 9. This therapy is given first to the parts most distal to the tumor, in most instances starting with irradiation over the chest and finally ending with the treatment of the primary tumor. This mode of treatment has resulted from our belief that irradiation itself is capable of producing changes which may tend to spread the malignant cells.

We have treated 12 patients with malignant tumors by this procedure. None of these patients had recognized metastases on admission, but in 2 instances the rapid development of an abdominal mass indicated that extension may have occurred before treatment was started. Eleven (91 per cent) of these patients are now living. The average length of life since treatment has been 5.2 years (Table VI). One of these

patients (O. S.) is suspected of having retroperitoneal metastases but has remained well for three and a half years (Table VI).

The second group includes those patients who were treated following orchidectomy and in whom no demonstrable evidence of metastasis was present when they appeared for radiation therapy. The treatment was delivered chiefly over the inguinal regions, the anterior and posterior abdomen and lumbar areas of the side involved, and in about half of the patients the treatment was extended into the chest. Each area received on an average of 800 to 1,600 r. The other physical factors were essentially the same as indicated in Figure 9. In this group of 16 patients 9 (56 per cent) are living without evidence of disease. The average length of life of those surviving is 7.5 years. The 6 patients who succumbed lived an average of fifteen months after removal of the tumor (Table VII).

A summation of the results in 28 patients with testicular tumors treated by irradiation before the onset of clinical evidence of metastasis can be seen in Table VIII. Of the 8 patients who succumbed to the disease, all died in less than two years. This information may be of some prognostic significance. Twenty of the 28 patients are living three or more years.

The third group of patients concerns those who had evident metastases when they first appeared for radiation therapy (Table IX). Most of these were patients who had a previous orchidectomy. Two came in with the primary tumor still present. In one (P. S.) the primary tumor was so small that it could not be found until one year after a laparotomy for an abdominal mass which proved to be the metastatic deposit from the testicle. The other patient (M. K.) did not have an operative removal of the testicle because of the hopeless prognosis. Gross statistics in this group of 17 patients mean very little. Some patients were in such extremely poor condition that adequate roentgen therapy could not be delivered. Some patients died a few days after the beginning of treatment. None of our patients who had a metastasis above the diaphragm has survived. Three patients with proved ab-

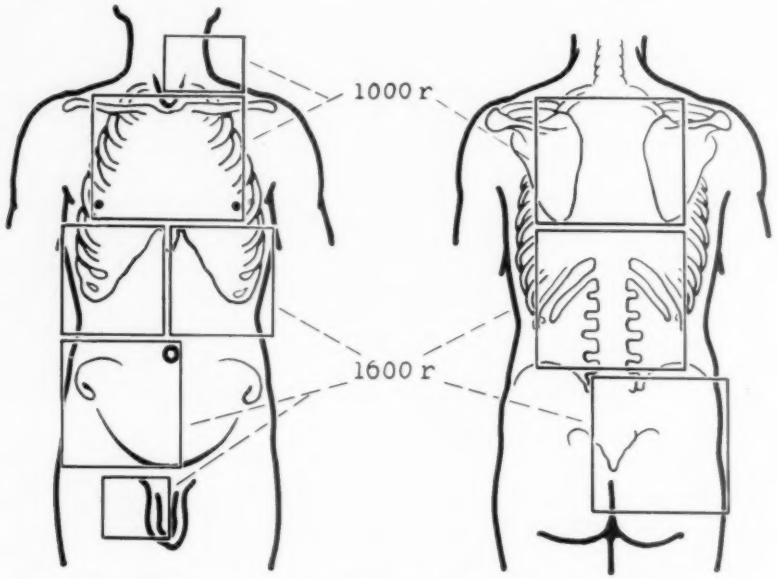

FIG. 9. Diagram showing type of preoperative irradiation used in this series. The portals over the neck and thoracic areas were irradiated first, then the upper abdominal and lower abdominal areas were treated, and finally irradiation was given to the primary tumor.

dominal metastases are now living, one four years and 2 thirteen years. Two of the 3 had had laparotomies at which time the lesions were considered inoperable. One had an autonephrectomy on the involved side with return of normal kidney function following radiation therapy. These 3 patients present certain points which warrant their presentation in greater detail. The first patient shows the early development of abdominal metastases, the value of excretory urography and the response of the metastatic lesions to moderately large doses of roentgen therapy.

TABLE VI

PREOPERATIVE IRRADIATION—NO EVIDENCE OF METASTASIS WHEN FIRST SEEN

Patient	Result	Time since Treatment
S. S.	Living and well	3½ yr.
H. E.	Living and well	3½ yr.
E. G.	Living and well	5½ yr.
J. P.	Living and well	4 yr.
L. S.	Living with heart disease	5½ yr.
C. S.	Living and well	8½ yr.
D. M.	Living and well	5 yr.
F. B.	Living and well	6 yr.
L. W.	Living and well	4½ yr.
O. S.	Living with probable metastases	3½ yr.
J. W.	Living and well	8½ yr.
F. M.	Dead	8 mo.

CASE 1. A. S., a white male, aged thirty-five, was first observed by us in March, 1937. He gave a history of painless swelling of the right testicle which had been present for two years. This tumor had been removed one month prior to admission in February, 1937. The microscopic diagnosis was seminoma. On admission he complained of pain in the right abdomen and edema of the entire right leg and thigh. There was a palpable mass in the right abdomen. The roentgen examination of the chest was negative. An intravenous urogram showed no function of the right kidney (Fig. 10*A*). The urinary prolan excretion from a twenty-four hour sample showed less than 50 mouse units per liter. Radiation therapy was delivered to portals in the right upper and lower abdomen anteriorly and posteriorly between March 30 and April 30, 1937. The anterior and posterior portal over the right upper abdomen received 1,850 r. Similar portals over the right lower quadrant received 2,000 r* each. By the end of this series a definite abdominal mass could no longer be palpated and the pain had disappeared. A urogram made in December, 1937, showed a return of the function in the right kidney (Fig. 10*B*). This patient has remained well and without evidence of recurrence up to the present time, a period of four years since his operation.

TABLE VII

POSTOPERATIVE IRRADIATION—NO EVIDENCE OF METASTASIS WHEN FIRST SEEN

Patient	Result	Time after Orchidectomy
J. C.	Living and well	5 yr.
M. K.	Living with hypertensive heart disease	7 yr.
M. H.	Living and well	10 yr.
T. B.	Living and well	13 yr.
J. W.	Living and well	6½ yr.
A. V.	Living with heart disease	8 yr.
B. B.	Living and well	5½ yr.
H. M.	Living and well	10 yr.
I. B.	Living and well	3 yr.
J. S.	Lost	—
J. D.	Dead	5 yr.
L. W.	Dead	16 mo.
H. A.	Dead	20 mo.
F. B.	Dead	18 mo.
C. H.	Dead	16 mo.
V. K.	Dead	12 mo.

The following case demonstrates the vague symptoms which occur with ab-

TABLE VIII

ANALYSIS OF 28 PATIENTS, WITHOUT METASTASIS WHEN FIRST SEEN TREATED WITH BY PRE- OR POST-OPERATIVE IRRADIATION FOR TUMOR OF THE TESTIS

	Less than 2 Years	3 to 5 Years	5 or More Years	Total
Living	0	6	14	20 (70%)
Dead or lost	8	0	0	8 (30%)

* All figures for dosage used in this paper refer to roentgens as measured in air. The half-value layer for 0.5 mm. Cu and 2 mm. Al is 0.88 mm. Cu, the effective wave length being 0.17 Å.

dominal metastases, the failure to discover metastases by physical examination until they become a large mass, and the inefficiency of small doses of roentgen therapy over the lower abdominal portals.

CASE II. N. R., a white man, aged fifty-six, first seen on September 20, 1928, gave a history of enlargement of the right testicle for one and one-half years. This was painless and the patient thought it was due to a hernia. A right orchidectomy had been done one week before at which time a tumor the size of a grapefruit was removed. Between October 8 and October 17 the patient was given radiation therapy over two inguinal portals. This treatment consisted of 300 ma-min. using 200 kv., 50 cm. distance, 0.5 mm. Cu plus 2 mm. Al filter. This was before the use of the roentgen as a unit of dosage and the exact dose in r cannot be given. Roughly, however, the dosage may have been of the order of 600 r to each of these two skin portals. Three months later, in January, 1929, the patient returned complaining of pain in the back and gas. These symptoms were not very severe and the patient believed that he was having "kidney trouble." He was given another series of roentgen treatments between January 10 and January 18. This consisted of approximately 600 r to the lower lumbar spine and approximately 300 r to each of two skin portals over the lower anterior abdomen. The factors were the same as previously. In April, 1929, he again returned and at this time there was a grapefruit-sized mass palpable in the right upper abdomen. Between June 27 and July 23 this mass was treated through one anterior and one posterior portal. The dosage used at this time corresponded approximately to 1,600 r to each area. An exploratory laparotomy on May 13, 1929, showed a pancake-like mass involving the retroperitoneal structures from the diaphragm to the pancreas on the right side of the abdomen. From October

TABLE IX

PATIENTS WITH METASTASES WHEN FIRST SEEN

Patient	Site of Metastasis	Adequately Treated	Interval from Operation to First Treatment	Pathological Diagnosis	Result
J. L.	Abdomen, Chest	No	4 mo.	Sarcoma	Died 4 mo. after orchidectomy
J. LEE	Skull, Chest	Not treated	1 wk.	Sarcoma	Died 5 mo. after orchidectomy
E. E.	Abdomen, Chest	No	9 mo.	Carcinoma	Died 12 mo. after orchidectomy
J. P.	Abdomen, Chest	Yes	10 yr.	Teratoma	Died 10½ yr. after orchidectomy
N. S.	Abdomen, Chest	No	1 mo.	Seminoma	Died 2 mo. after orchidectomy
A. MC.	Abdomen, Chest	No	3 mo.	Mixed tumor	Died 19 mo. after orchidectomy
J. B.	Abdomen	Yes	7 mo.	Sarcoma	Died 6 yr. after orchidectomy
S. H.	Abdomen	No	4 mo.	Sarcoma	Died 4 mo. after orchidectomy
A. M.	Abdomen	No	1 mo.	Sarcoma	Died, date unknown
D. J.	Abdomen	No	7 mo.	Sarcoma	Died 15 mo. after orchidectomy
R. F.	Abdomen	No	2 mo.	Embryoma	Died 2 mo. after orchidectomy
A. F.	Abdomen	Yes	18 mo.	Embryoma	Died 2½ yr. after orchidectomy
P. S.	Abdomen	Yes	None	Teratoma	Died 2 yr. after orchidectomy
M. K.	Abdomen	Yes	No operation	—	Died, date unknown
A. S.	Abdomen	Yes	1 mo.	Seminoma	Living, 4 yr. after orchidectomy
N. R.	Abdomen	Yes	8 mo.	Teratoma	Living, 13 yr. after orchidectomy
E. S.	Abdomen	Yes	12 mo.	Teratoma	Living, 13 yr. after orchidectomy

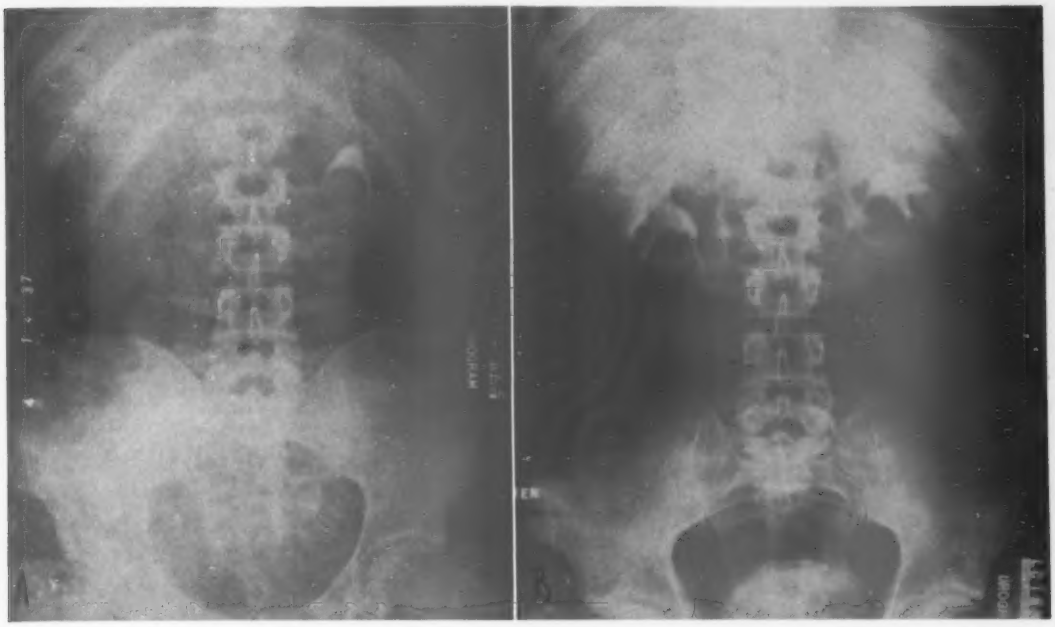

FIG. 10. *A*, intravenous urogram of a patient with a right testicular tumor. A palpable mass was present in the right abdomen. The right kidney does not function. *B*, intravenous urogram of same patient following radiation therapy. The palpable mass disappeared and the renal function has returned.

15 to November 4 the patient was again treated over skin portals covering the upper and lower abdomen. At this time he received approximately 600 r×4. In January, March and October, 1930, similar series of treatments were given. The palpable mass could not be felt after the treatment in March and this patient returned to his work and was well when last heard from in March, 1937, thirteen years after orchidectomy.

A third case illustrates the value of radiation therapy in what was apparently an inoperable and hopelessly involved abdominal mass.

CASE III. E. S., a white male, aged twenty-seven, was first seen in March, 1930. In November, 1928, an embryonic carcinoma of the left testicle had been removed. One year later, November, 1929, he had received roentgen treatment for an elastic mass in the left flank just below the left kidney. An exploratory laparotomy was subsequently done and a large inoperable mass of tumor tissue was exposed. Some tissue was removed which was considered, by histological examination, as being of a radioresistant type. Between May, 1930, and May, 1931, this patient received a large amount of radiation therapy in the form of radium and roentgen rays. The mass in the left abdomen gradually became smaller but it has never entirely disappeared. This patient has been followed carefully for the past eleven years and he is well in spite of the fact that he has a palpable lesion in the left upper abdomen.

The average length of life following orchidectomy, or the first treatment, was twenty-five months for the 14 patients in this group who have died. For the 3 who have lived the average is ten years.

Malignant tumors of the testicle have a poor prognosis. Table X shows the results for the entire series of 45 patients. Only 35 per cent of our patients have lived five or more years. From Table XI it is evident that the duration of symptoms before treatment had no effect on the end-results

TABLE X

END-RESULT IN 45 PATIENTS WITH TUMOR OF THE TESTIS

Total number of patients living	23 (51%)
Number of patients living 5 or more years	16 (35%)

TABLE XI

RELATION OF THE INTERVAL BETWEEN THE FIRST SYMPTOM AND THE FIRST TREATMENT TO THE FINAL RESULT IN 36 PATIENTS

Duration of Symptoms	Living	Dead
Six months or less	10	10
Six months to one year	4	3
More than one year	5	4

in this series. Such figures, however, must only be considered in the light of definite knowledge of the time of onset of the tumor. In most instances this is not reliable because the tumor is usually unnoticed for an indefinite period. As stated before, metastases are prone to occur early in the majority of instances so that some other factors play a part in the subsequent course of the disease. It is of interest that the statistics in this series indicate that 37 per cent of the patients who first came with evident abdominal metastases and who subsequently obtained adequate radiation therapy have lived on an average of more than five years and 50 per cent of those who had no demonstrable metastases when first seen and who were treated by irradiation with orchidectomy survived a similar period. It may be suggested from these figures, as well as from other sources of information, that metastases were already present in the latter group at the time of treatment, the only difference being the inability to detect such lesions by the usual methods of examination. Radiation therapy, either by radium or roentgen rays, has saved the life of 3 patients of the group of 17 with abdominal metastasis in our series (Table XII). Patients without clinical evidence of metastasis when first seen have five year survival figures which have been increased by modern therapeutic irradiation from 6 per cent (Tanner,[18] Wasterlain[19]) to 50 per cent in this series. Dean[4] has observed 60 per cent five year cures in a similar group of patients. Such evidence as this seems to leave no arguments in favor of surgery alone.

TABLE XII

PATIENTS WITH METASTASES WHEN FIRST SEEN

Total Number of Patients	Total Number of Patients Living	Number of Patients Considered as Having Adequate Treatment	Number of Patients Living Who Had Adequate Treatment
17	3(17%)	8	3(37%)

From the foregoing data is it possible to prepare an ideal course of treatment for a patient with a primary testicular tumor? Before attempting to do this, certain questions should be answered. Is it always advisable to give preoperative irradiation to a patient with a testicular tumor? From the preceding data it is suggested that these tumors be treated with irradiation before they are removed, except in those patients who undoubtedly have an adult type of teratoma. The immediate survival rate in our series was 35 per cent greater in those patients who received preoperative irradiation than in those who received postoperative treatment. Dean found that the number of five year survivals in his series was 22 per cent greater if preoperative irradiation was given. In giving preoperative irradiation over the lymphatics before there is clinical evidence of a metastasis, the radiologist carries a psychological burden. The metastatic cells cannot be felt or seen and the tendency is to undertreat or to try to sterilize the field by giving small doses. These patients should be treated as though an evident metastatic tumor were present since the radiosensitivity of the cells is the same in the two instances. An adult type of teratoma may be suspected when a patient gives a history of a slowly growing tumor or one which has been present over a period of years. In such a case, the prolan excretion is low and the roentgenogram of the testicle may show calcification. Because there is no histological evidence that irradiation affects this type of tumor, it may be removed without irradiation, although in most instances it is safer to precede the orchidectomy by a course of radiation therapy.

If preoperative irradiation is given, should it cover the entire lymphatic drainage or should it be confined to the primary tumor? The initial course of radiation therapy should be so outlined that it covers the primary and secondary lymphatics below the diaphragm. The areas over the upper abdomen should be treated first, leaving the irradiation of the testicular tumor for the last part of the series. If the tumor is radiosensitive then one should proceed immediately with irradiation over the thorax and supraclavicular region. If the tumor proves to be totally radioresistant, no further treatment is necessary. Such a course is advantageous because it reduces the time of treatment by about ten to twelve days and therefore gives an earlier opportunity for orchidectomy; secondly, it allows a time interval for the recovery of a depleted bone marrow before irradiation is given over the ribs, thoracic spine and sternum. While the latter is not often a serious complication it may limit the amount of radiation therapy which can safely be given. Figure 11 shows the drop in the leukocyte count which occurred in one of our patients. This patient had an average of 550 r to each of nine portals over the entire trunk and lower neck between February 23, 1937, and March 30, 1937. The lowest blood count was 1,500 leukocytes with 80 per cent hemoglobin.

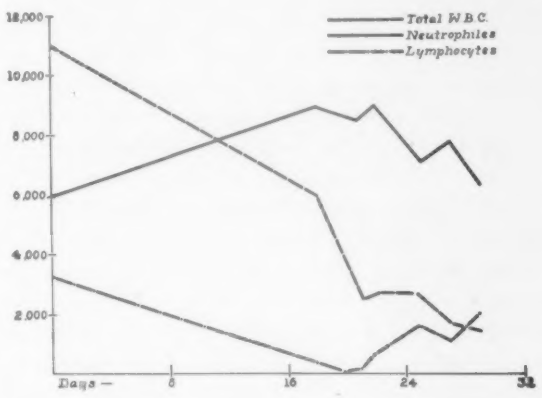

FIG. 11. Diagram showing the effect of irradiation over the ribs, sternum, spine and pelvis of a patient being treated for testicular tumor. The total white count dropped below 2,000 during the course of therapy.

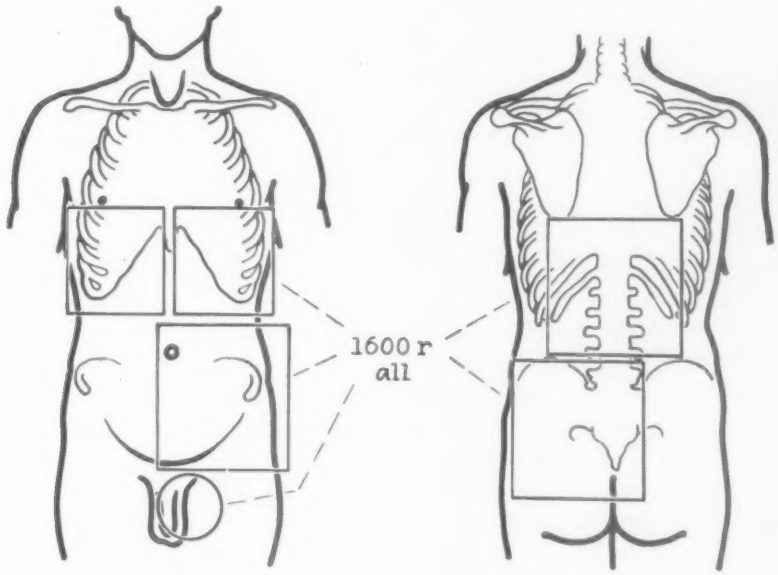

FIG. 12. Diagram of proposed form of preoperative radiation therapy to be given to a patient with tumor of the testis. The upper abdominal portals should be treated first. These areas should cover the abdomen below the diaphragm. The lower abdominal areas should be placed to the side of the tumor but should extend slightly across the midline. No appreciable area between the borders of the portal over the testicular tumor and the anterior lower abdominal portal should be left untreated.

How long should one wait after preoperative irradiation before doing an orchidectomy? Histological evidence would indicate that the greatest amount of vascular damage occurs about the fifth week following irradiation. The speed and amount of regression will depend upon the radiosensitivity of the tumor cells. If the tumor becomes smaller following irradiation it should be removed about four to six weeks after treatment. If no regression has occurred, it should be removed as soon as the irradiation reaction on the skin has subsided.

A proposed course to follow in any patient with a primary testicular tumor is, therefore, prompt diagnosis by history and physical examination, prolan studies of the urine, excretory urogram, roentgenogram of the tumor, roentgenograms of the chest, and preoperative irradiation over the lymphatics in the abdomen and then over the tumor. If regression occurs, an orchidectomy should be done in a few weeks and the chest and supraclavicular region irradiated after operation (Fig. 12).

CONCLUSIONS

A. Forty-five patients with tumor of the testis have been studied with the following conclusions:
   (1) The incidence of malignant tumor of the testis is 1 per cent of all malignant disease.
   (2) Tumor of the testis occurs at any age but is most common between the ages of twenty and forty.
   (3) Various pathological diagnoses are given depending upon the predominating cell type, but for the purpose of therapy it is important only to determine the radiosensitivity of the cells comprising the tumor.
   (4) The symptoms of the primary tumor of the testicle are often vague. Pain is uncommon. Pain in the back or "indigestion" in a patient with a primary tumor of the testis frequently indicates retroperitoneal metastases. Gynecomastia is uncommon and probably not significant.
   (5) Preoperative diagnosis of tumor of the testis is made by careful clinical and laboratory studies. Certain information can be obtained by exclusion of other lesions such as syphilis, tuberculosis and hydrocele. Urinary prolan studies are not always helpful and in some cases may be misleading. Excretion urography may demonstrate evidence of abdominal metastases before there is any other clinical evidence. The response of the lesion to radiation therapy is sometimes a reliable diagnostic sign.
   (6) Metastases from testicular tumor are prone to occur early and frequently lodge in the retroperitoneal lymphatics surrounding the aorta and inferior vena cava. The two types of extension to the thorax, lymphatic and hematogenous, can be recognized by their roentgen appearance.
   (7) The results of the treatment indicate that 91 per cent of a group of 12 patients who received irradiation followed by orchidectomy are living and well; 56 per cent of a group of 16 patients who had orchidectomy first and irradiation after are living and well; 17 per cent of a group of 17 patients who had clinical evidence of abdominal metastases when first seen are living and well. Those patients, who have died, lived only an average of twenty-four months after they were first seen.

B. The literature regarding therapy and prognosis of tumor of the testis is discussed in the light of some recent ideas, and an attempt has been made to answer certain questions pertinent to the treatment of these patients.

C. An outline of a therapeutic course is presented for a hypothetical patient with malignant disease of the testicle.

REFERENCES

1. Bailey, H. Malignant disease of the testicle. *J. Roy. Nav. M. Serv.*, 1939, *25*, 124–129.
2. Brunschwig, A., and Fox, J. Correlation of roentgen ray dosage and necropsy findings in a case of retroperitoneal and mediastinal metastases from embryonal carcinoma of the testis. *Ann. Surg.*, 1937, *105*, 265–269.
3. Cabot, H., and Berkson, J. Neoplasms of the testis. *New England J. Med.*, 1939, *220*, 192–195.
4. Dean, A. L., Jr. Teratoid tumors of the testis. *J. Am. M. Ass.*, 1939, *105*, 1965–1971.
5. Desjardins, A. U., Counseller, V. S., and Gianturco, C. Results of treatment in tumors of the testis. *Am. J. Surg.*, 1935, *27*, 71–78.
6. Entwisle, R. M., and Hepp, J. A. Testicular chorionepithelioma with gynecomastia and complete pregnancy reactions. *J. Am. M. Ass.*, 1935, *104*, 395–396.
7. Heidrich, L., Fells, E., and Mathias, E. Testicular chorionepithelioma with gynecomastia giving rise to signs of pregnancy. *Beitr. z. klin. Chir.*, 1930, *150*, 349–384.
8. Higgins, C. C., and Buchert, W. I. Malignant tumors of the testicle. *Am. J. Surg.*, 1939, *43*, 675–687.
9. Hinman, F. Tumors of the testis. *Surg., Gynec. & Obst.*, 1933, *56*, 450–461.
10. Hinman, F. The Principles and Practice of Urology. W. B. Saunders Co., Philadelphia, 1935, p. 763.
11. *Idem.*, p. 783.
12. Jameison, J. K., and Dobson, J. F. Lymphatics of the testicle. *Lancet*, 1910, *1*, 493.
13. MacKenzie, D. W., and Ratner, M. Metastases from tumors of the testis. *J. Urol.*, 1939, *41*, 592–610.
14. Owen, S. E., Polanco, Q. G., and Prince, L. H. Urine chemistry in diagnosis of embryonal tumors. *Am. J. Cancer*, 1937, *31*, 613–617.
15. Pendergrass, E. P. Personal communication.
16. Randall, A., and Bothe, A. E. Value of preoperative irradiation in tumor of the testis. *Ann. Surg.*, 1937, *105*, 385–391.
17. Smith, G. G., Dresser, R., and Mintz, E. R. Radiation treatment of tumors of the testicle. *J. Urol.*, 1935, *34*, 462–469.
18. Tanner, C. O. Tumors of the testicle, with an analysis of one hundred original cases. *Surg., Gynec. & Obst.*, 1922, *35*, 565.
19. Wasterlain, A. Quoted by Dean, ref. 4.

THE EFFECT OF A VITAMIN B COMPLEX DEFICIENCY ON GASTRIC EMPTYING AND SMALL INTESTINAL MOTILITY

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DURING the last decade, as the composition of the vitamin B complex has become better understood, there has been an increasing interest in the part which the components of the vitamin B complex play as therapeutic agents. Although it has been known that the vitamin B complex affects the physiology of the gastrointestinal tract, very little is known concerning the effects on this tract as determined by roentgenologic study.[4,7,13] Cowgill and his associates[4] have reported that gastric atony will result from a vitamin B complex deficient diet and have shown that the feeding of liberal quantities of yeast helps to maintain proper gastric tone. They suggested that the action of the vitamin B complex has more than a local effect in that following vitamin B therapy the appetite returns before the normal gastric tone is re-established. Gross[7] timed the intestinal motility in rats on vitamin B deficient diets by feeding food mixed with charcoal. He found that constipation invariably developed, this being subsequently relieved by adequate doses of yeast.

Hargreaves, Fletcher and Dickson,[8] studying the motor function of the colon in vitamin B_1 deficient rats, showed an increase in the length of the colon, and other evidences of lack of tone as revealed by the low position of the cecum in the abdomen and evidences of ileocecal sphincter incompetency.

Menville, Ané and Blackberg[13] studied the gastrointestinal tract of rats on vitamin B deficient diets roentgenoscopically with a barium sulfate and buttermilk meal. In vitamin B deficient rats they found marked hypomotility as shown by (1) delayed gastric emptying time, and (2) delayed small and large intestinal motility.

One of the underlying causes of the disturbances in motility may be the degenerative changes in Auerbach's plexus in vitamin B deficient animals reported by McCarrison.[11] Findlay,[6] in a study of vitamin B deficient rats, found histological changes in the alimentary tract. He reported atrophic changes involving the lymphoid tissues and musculature of the intestine together with evidences of congestion in the submucosa. The histological changes in the liver, pancreas and suprarenals were those ordinarily associated with inanition. Though death occurred almost invariably in his vitamin B deficient rats, a careful study of the tissues, even the finer cytologic investigation of the mitochondria, failed to reveal an adequate cause.

Elsom,[5] in a recent paper on vitamin B deficiency in man, called attention to the fact that symptoms of glossitis, heartburn, and anorexia are accompanied by "roentgen evidence of altered tone in the gastrointestinal tract, the stomach becoming atonic and the small intestines displaying irregular areas of increased and decreased tone." This description is in accord with the findings of Snell and Camp[18] who, in idiopathic steatorrhea, found from time to time a change in the caliber of the small bowel. They found that "smooth and apparently narrowed regions later were dilated, suggesting the presence of spasm." A similar appearance characterized by lak-

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ing, stasis and dilatation of the small bowel has been described by Pendergrass and Comroe[14] in chronic idiopathic adult tetany.

Mackie and Pound[10] have described changes in the gastrointestinal tract in man in certain deficiency states. Their patients were suffering from a general deficiency but presented abnormalities such as are found in sprue, pellagra and beriberi. Roentgenologically they noted widening of the duodenum, thickening of the valvulae conniventes in the jejunum, and segmentation of the intestinal contents into sausage-shaped coils. The authors felt that reduction in muscle tone was the outstanding feature of the roentgen picture. The cause for the hypotonicity was attributed to the lack of the antineuritic principle.

Synthetic thiamin hydrochloride, nicotinic acid and lactoflavin have been available for such a relatively short time that few studies have been completed which would serve properly to evaluate the effect of each of these on gastrointestinal activity. It is of interest that in a recent review[3] of the physiology of vitamin B_1 no mention was made of roentgen observations in evaluating the motility of the stomach and intestines. The present study concerns itself with the effect of these components on the gastrointestinal appearance and motility of vitamin B deficient dogs as determined by carefully controlled roentgenologic examinations.

METHOD

The animals were young adult dogs weighing from 7 to 9 kilograms. The dogs were dewormed and placed on the modified Cowgill casein diet.[1] Following a two weeks' trial test those dogs which took the diet poorly were discarded. Roentgenograms, however, were made of all of the animals during this period in order to determine the appearance and motility of the gastrointestinal tract before the vitamin B deficiency states were induced. A control dog was kept for each experimental dog. In the experimental group the commercial casein was replaced by a vitamin-free casein (Labco) and the brewers' yeast was withdrawn from the diet. Vitamins A and D were supplied daily in the form of cod liver oil (0.2 cc. per kilogram of body weight). Vitamin C was not given as it has been shown that dogs synthesize their own.[1] The control dog for each experimental animal received an amount of food and water equal to that consumed on the previous day by his experimental partner and in addition 1 gram of brewers' yeast per kilogram of body weight per day. Both the experimental and control animals were weighed weekly.

The procedure for roentgen examination of the dogs, control and experimental, was as follows. The animals were starved for twelve hours prior to the examination. With the aid of roentgenoscopy a small caliber stomach tube was inserted through the cardia and 3 ounces of a 5 to 6 barium mixture (water 5 parts and barium sulfate 6 parts) were injected into the stomach, the tube then being withdrawn. The progress of the meal was then studied roentgenoscopically and roentgenograms were made at stated intervals, the first at twenty minutes, the second at one hour, and subsequent exposures at hourly intervals, until the head of the barium meal had reached the cecum. In those few instances when the barium had entered the cecum between exposures, the cecum appearance time was estimated.

The animals were allowed to progress in their vitamin B deficiency until clinical and roentgenological changes became quite evident. Then 1 milligram of crystalline thiamin hydrochloride was given per day subcutaneously. The roentgen observations were then continued throughout the period of vitamin B_1 therapy. Finally, when crystalline thiamin hydrochloride had been administered to the dogs for a sufficient period to overcome a vitamin B_1 deficiency, they were given nicotinic acid (100 mg. per day orally) and lactoflavin (1 mg. every other day subcutaneously). However, none of the animals lived for a sufficient length of time to permit an evaluation with any degree of accuracy as to what therapeutic or physiological properties these latter two substances might have had.

RESULTS

The food intake of the animals was normal for approximately seven days but thereafter anorexia was noted and there were alternating periods when food was rejected, and times when all food offered was eaten. At no time, even toward the end of an experiment, were there more than

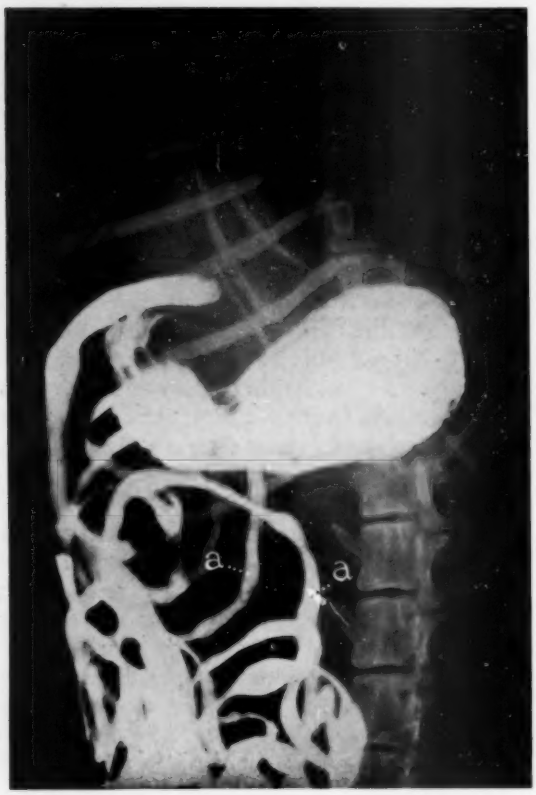

FIG. 1. Stomach and small intestine of the normal dog fifteen minutes after water-barium meal. Note the normal ribbon-like small intestinal stream at *a*.

five or six successive days when no food was ingested. The onset of anorexia was in general so rapid that a single therapeutic dose of 0.5 mg. of crystalline vitamin B_1 was given on the thirteenth day to determine whether or not the loss of appetite occurred as the result of a vitamin B_1 deficiency. This procedure, as a rule, produced a prompt but temporary rise in the food intake. Following this there was a gradual downward trend in food and water consumption until the animal developed a B_1 deficiency as determined by clinical, neurological and suggestive roentgenological evidence.

The time for the appearance of the vitamin B_1 deficiency varied from twenty-eight to forty-two days. The regular administration of crystalline vitamin B_1 was then begun. To the animals that developed convulsions, massive doses of crystalline vitamin B_1 were given subcutaneously and intravenously, along with glucose and saline and general supportive measures. Only one of the animals that developed convulsions survived. In each instance, spasticity of the hind quarters preceded the convulsions by two to three days. In 2 dogs diarrhea occurred and in one the stools were blood streaked for two days prior to the development of spasticity.

The food intake following the daily administration of crystalline vitamin B_1 increased for from five to fifteen days, but then again there was a gradual decline in appetite though not as marked as during the vitamin B complex deficiency. The final daily oral administration of 100 mg. of nicotinic acid and the subcutaneous injection of 1 mg. of lactoflavin, every other day, resulted in a suggestive rise in food

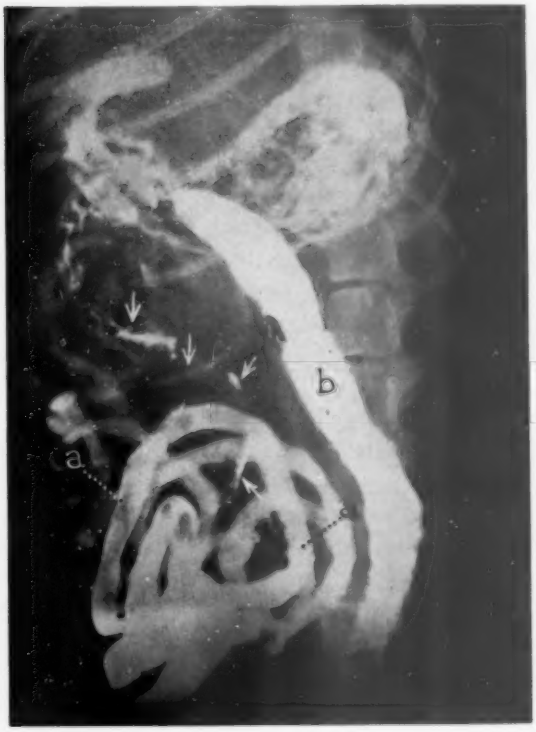

FIG. 2. Showing the ribbon-like mucosal relief at *a*. After the water-barium meal passes along the small bowel of the normal dog, it leaves a suggestive mucosal pattern (see arrows). There is a barium residue in the large bowel from the previous examination at *b*. Compare the lumen of the small bowel at *a* with that of the colon at *b*.

intake but this was not significant and the general condition of the dogs was not one of marked improvement. The loss of weight in the experimental dogs was marked. In each there was a temporary stay or gain in weight upon beginning the administration of crystalline vitamin B_1 but as a rule the weight curve continued downward. The average weight loss was 33.7 per cent per dog. The paired control dogs, on the other hand, showed no loss greater than 17 per cent. One dog even showed a slight gain. This would indicate that the vitamin B deficient dogs failed to utilize some of the food which was ingested.

The water intake paralleled the food consumption up to the time of the institution of crystalline vitamin B_1 therapy, when water consumption increased greatly while food intake increased only temporarily.

The generalized dermatitis with marked alopecia and ulcerations over the bony prominences appeared in from sixty to eighty days after the vitamin B free diet was started and was not affected by the administration of crystalline vitamin B_1. These lesions did, however, gradually heal and the hair returned in one instance upon the prolonged administration of brewers' yeast. The dermatitis took much longer to disappear. None of the control dogs developed the dermatologic or neurologic signs of a vitamin B deficiency.

Fig. 3. Vitamin B complex deficiency. Film made four hours after adminstration of water-barium meal. Gastric retention is observed at *a*. Note the decrease in the small intestinal lumen at *b*. The size of the lumen changed from time to time roentgenoscopically; we interpreted such observations as spasm. The lumen of the small intestine at *b* was smaller than that observed in the normal control. Compare with Figure 2, *a*. The general reduction in the lumen of the small intestine was interpreted as being due to an increased tonus.

ROENTGEN CONSIDERATIONS

Our observations on the gastric emptying time in the dogs before the vitamin B deficiency state was induced were in close agreement with those previously obtained here by Mecray, Barden and Ravdin.[12] Utilizing a similar water-barium meal they found that the gastric emptying time varied from one hour and thirty-five minutes to two hours. We found that if cod liver oil was excluded from the diet on the day of the examination, there was no gastric residue at the end of two hours; if, however, cod liver oil was given, gastric emptying time was often delayed up to four hours. This observation, likewise, is in agreement with the work of Ravdin, Pendergrass, Johnston and Hodes[16] who had previously shown that fats produced a marked delay in gastric emptying time in man and dog.

In the normal state prior to the beginning of the vitamin B deficient diet, the small intestinal stream of the dog was ribbon-like in form. There were moderate variations in the lumen or size of the small intestinal canal. The small intestinal stream was continuous. At no time was seen the mucosal pattern such as is observed in the human intestine. The only exceptions to this state-

ment occurred after the major portion of the small intestinal stream had progressed, leaving behind small patches of barium, which produced a fine pattern that simulated the snowflake appearance seen in the human jejunum (Figs. 1 and 2). Even in control dogs which had been almost completely starved for several days, there was very little variation in motility and appearance from that detailed above.

(Figs. 3 and 4). The cecum appearance time in the same period increased from a normal average of one hour and forty-eight minutes to three hours, paralleling to a lesser degree, the delay in the gastric emptying.

Certain changes were also noticed in the small intestinal stream. The reduced lumen of the small intestine was interpreted as being the result of hypertonicity. Not in-

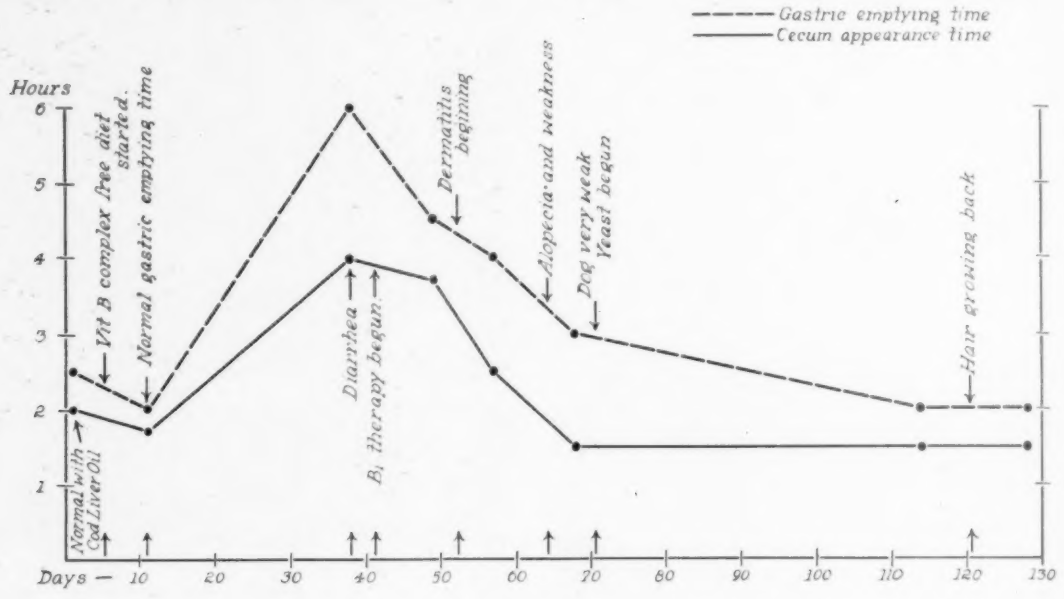

FIG. 4. Gastric emptying and cecum appearance time in a dog on a vitamin B complex-free diet and after the administration of vitamin B_1 and whole yeast.

An interesting observation was that, unlike the findings in man, a small amount of intestinal gas was present normally in the dog. When the animals were placed on the vitamin B deficient diet a severe anorexia usually manifested itself between the twenty-eighth and forty-second day. In 2 of our animals convulsions occurred on the thirty-first and thirty-eighth days respectively, after beginning the diet. The maximum changes in gastrointestinal activity were noted, as a rule, just prior to the onset of spasticity in the hind legs. Gastric emptying, during this period, had increased from an average normal of one hour and fifty-four minutes to an average of five hours and twelve minutes (extremes four hours and twenty minutes and six hours)

frequently during the roentgenoscopic examination marked transient variations in the size of the lumen would occur. Such findings were interpreted as alternating spasm and relaxation. There was, however, one notable exception in which the diminished caliber of the bowel persisted for approximately six hours, and produced a rather characteristic "string of beads" appearance (Fig. 5). Many peristaltic rushes were observed within these loops, but the total motility was impaired; that is, the peristaltic rushes seemed to be confined to a limited portion of the gut and the head of the meal required a longer time to reach the cecum. These findings came as a surprise, as we had expected to see evidence of atony and dilatation in most portions of

the intestinal tract. As will be seen later, these appearances were the early manifestations of the deficiency state.

In view of the fact that the dogs were not examined in the erect posture, it was practically impossible for us to evaluate minor changes in gastric tonus with any degree of accuracy. Even in the presence of gastric atony, and even when marked inanition supervened, gastric peristalsis was never absent. Indeed, deep peristalsis without commensurate motility was often apparent, and absence of peristalsis in the most severe state of deficiency was rather the exception than the rule.

Following administration of vitamin B_1 to the deficient dogs, and paralleling their temporary return of appetite, an improvement in the intestinal gradient was noted by roentgen study. However, complete restitution of normal motility did not take place. Complete recovery of normal motility and configuration occurred only after the administration of whole yeast.

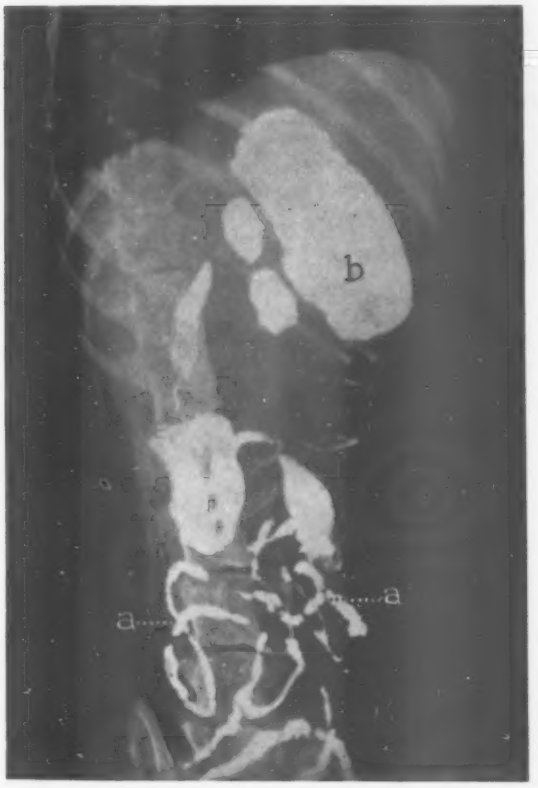

Fig. 5. Vitamin B deficient animal, six hours after the administration of a water-barium meal. Note the "string of beads" small intestinal stream at *a*. There is a gastric residue at *b*.

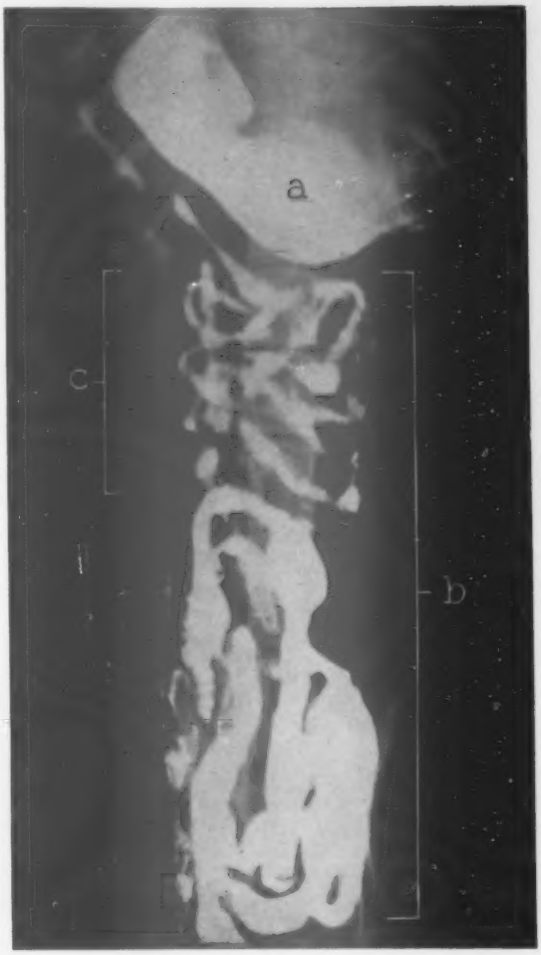

Fig. 6. Roentgenogram of an animal receiving adequate vitamin B_1 but deficient in the remainder of the vitamin B complex. The dog was first made completely vitamin B deficient and then received vitamin B_1 parenterally for sixty-six days before this roentgenogram was made. Note the two hour gastric residue at *a*. The continuous small intestinal stream is observed at *b*. Note the granular appearance of the barium in the proximal loops at *c*.

The gastric emptying time after vitamin B_1 therapy was approximately three hours (normal average one hour and fifty-four minutes) while the cecum appearance time was approximately two hours (normal average one hour and forty-eight minutes). Ab-

FIG. 7. Roentgenogram obtained twenty minutes after water-barium meal on a vitamin B complex deficient dog after twenty-five days of parenteral vitamin B_1 therapy. Note the early filling (twenty minutes) of the intestinal tract and the elongated appearance of the small intestinal stream.

normal changes in appearance persisted in spite of the parenteral administration of crystalline vitamin B_1 in rather large doses. These consisted of (1) a coarsely granular appearance of the barium in the intestines (Fig. 6); (2) elongation of the barium stream; that is, the barium instead of occupying several adjacent loops of the small bowel was frequently found not only in the entire small intestine but also the stomach and large bowel as well; (3) associated with this, one occasionally noted rapid early gastric emptying (Fig. 7), but with a residue at the three hour period. Such an observation has been observed in patients with hyperthyroidism.[15] (4) In some instances we noted a segmented effect in the small intestinal stream due to what we have interpreted as spasm. Interspersed between these areas were sausage-shaped dilated loops (Fig. 8). These appearances were not unlike those observed in non-tropical sprue. (5) Occasionally a nearly normal small intestinal picture was observed. No marked changes were seen in the gastric or intestinal peristalsis after beginning the vitamin B_1 therapy. In one instance, even after the vitamin B_1 therapy, the stomach appeared to be dilated. This dog had been on a vitamin B deficient diet for forty-six days and on a similar diet, to which thiamin hydrochloride had been added, for seventy-six days.

None of the dogs received lactoflavin and nicotinic acid for long periods, and therefore an evaluation of the changes which could be accounted for on the basis of their

FIG. 8. Sausage-shaped loops in a vitamin B deficient dog receiving vitamin B_1 parenterally are observed at *a*.

administration was difficult. On two occasions, however, the use of lactoflavin appeared to result in improvement; in one instance, there was less delay in gastric emptying, and in the other an improvement was observed in the appearance of the small intestinal stream.

Although no special attempt was made to study the large bowel, in several instances in the vitamin B complex deficient dogs an abnormal barium residue was noted in the colon. In one dog extreme obstipation was encountered, there being an eight day colonic residue (Fig. 9). In another case, roentgen changes similar to those seen in early ulcerative colitis were found.

Our results in the dog indicate that in a vitamin B complex deficiency, a delay in gastric emptying time up to six hours and a delay in cecal appearance time up to four hours are to be expected. The most constant small intestinal appearance in association with this deficiency was diminution in the caliber of the small bowel which we have attributed to hypertonicity. Following the administration of crystalline vitamin B_1 the loss of gradient was partially, though not wholly, corrected. Various abnormalities in the small intestinal pattern persisted in spite of the further administration of nicotinic acid and lactoflavin. Only after the administration of whole yeast was complete restoration to the normal observed (Fig. 10).

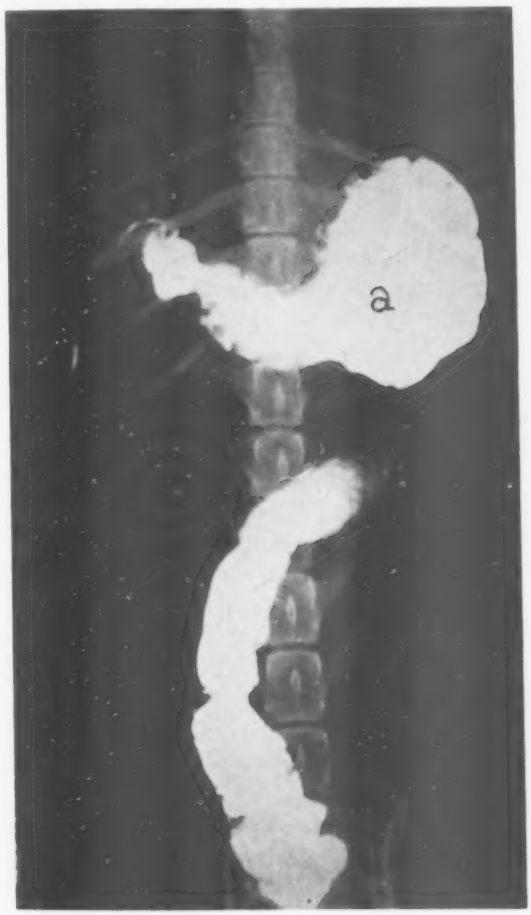

Fig. 9. Roentgenogram showing barium in large bowel eight days after previous examination. The barium in the stomach at *a* has just been instilled.

Fig. 10. Normal roentgenogram obtained after the administration of yeast to a vitamin B deficient dog. At *a* is seen an appearance not unlike the snowflake pattern occurring in the human jejunum after the major portion of the small intestinal bolus has advanced.

DISCUSSION

We have presented in detail our observations in vitamin B deficiency in the hope that these may serve as a basis for further investigation. The explanation of many of the various phenomena noted is admittedly obscure. However, certain of our findings suggest a possible clinical correlation.

It would appear that there is a tendency toward hypertonicity of the small intestine early in the acute phase of a vitamin B complex deficiency. The other appearances, some atonic in type, which later become manifest, more nearly resemble those observed in the multiple vitamin deficiencies of adults (Elsom,[5] Mackie and Pound[10] and Snell and Camp[18]). The granular effect which we have noted in the small intestines in some respects resembles the "moulage sign" of Kantor[9] as seen in idiopathic nontropical sprue, in which cases the fine mucosal pattern of the normal is wiped out and replaced by a coarser distribution of the barium. The restitution of the normal intestinal appearance following the administration of whole yeast suggests that the underlying cause is reversible. It is of interest that in patients Kantor has shown that the changes characterizing the "moulage sign" are also reversible.

Another point of interest is the similarity of some of the findings in our dogs to those seen in human hyperthyroidism in which there is frequently immediate partial gastric emptying but the total emptying time of the stomach is delayed above normal[15] (Fig. 7). As a result there is an elongation of the barium stream. These findings are particularly significant when we consider the well known relationship which exists between the metabolic rate and the vitamin B requirements, for as has been shown by Cowgill,[1] the tendency for the vitamin B requirements increases as the metabolic rate increases.

Sebrell[17] has said, regarding the treatment of pellagrins that, "although it may be desirable at some future time to attempt to prevent pellagra by the use of nicotinic acid mixed with some commonly used southern article of diet, the safest procedure at present would appear to be to continue vigorously our efforts to prevent the disease by improving the diet, using nicotinic acid as individual circumstances indicate, and leaving the possibility of its uncontrolled administration to a large section of our population until additional information is available."

Our preliminary findings point to a similar conclusion, for in no case have we been able to prevent death of the experimental animals with a combination of crystalline vitamin B_1, nicotinic acid and lactoflavin. It may be that the addition of other components of the vitamin B complex may change the picture, or it may even be that in dogs other factors in yeast now unknown may also play a part. It would appear that the treatment of hypomotility of the gastrointestinal tract in vitamin B deficiency demands other factors contained in whole yeast that are not supplied in lactoflavin, thiamin hydrochloride and nicotinic acid.

SUMMARY

1. In the experimental animals there was a marked drop in food intake in from five to fifteen days with periods of increased consumption occurring spasmodically thereafter.

2. The weight loss in vitamin B deficient dogs was considerably in excess of that of the food and water control animals.

3. Upon administration of vitamin B_1 there was a prompt increase in food intake with corresponding gain in weight, but this effect lasted only from five to fifteen days, followed by another decline.

4. Nicotinic acid and lactoflavin exerted little if any change in the downward course of the animals.

5. The water consumption increased out of proportion to the food intake upon administration of vitamin B_1, this disproportionate increase persisting although the amount of food consumed fell upon the prolonged administration of vitamin B_1 alone.

6. Dermatitis and alopecia with ulceration over the bony prominences were unaffected by vitamin B_1 therapy. The appearance of these manifestations came

sixty to eighty days after the beginning of the vitamin B complex deficient diet regardless of the administration of vitamin B_1.

7. The dogs developing spastic hind legs ordinarily showed evidence of convulsive seizures two to three days thereafter, and only one dog in convulsions responded to the administration of vitamin B_1 in therapeutic doses and intravenous glucose.

8. Cod liver oil slowed the gastric emptying time and cecum appearance time, without disturbing the appearance of the intestinal pattern.

9. Vitamin B complex deficiency caused marked retardation in gastric, and moderate delay of the small intestinal motility.

10. In vitamin B complex deficiency in the dog there is no typical small intestinal appearance evident although marked changes of various types have been noted, most consistent of which is diminished bowel caliber with a hypertonic appearance. Associated with this there were active peristaltic rushes within limited portions of the intestine without total increased motility. A "string of beads" pattern and a granular appearance of the barium in the small intestine were noted.

11. After crystalline vitamin B_1 administration there was a temporary return toward normal motility, but complete restitution of normal motility did not occur unless whole yeast was given by mouth. With prolonged vitamin B_1 administration in otherwise vitamin B deficient dogs, a delay in the gastric and small intestinal motility tended to recur.

12. Colonic stasis was frequently observed in the vitamin B deficient dogs.

13. Food and water control dogs did not show significant deviations from the normal small intestinal motility and pattern.

REFERENCES

1. Cowgill, G. R. Improved procedure for metabolism experiments. *J. Biol. Chem.*, 1923, *56*, 725.
2. Cowgill, G. R. Studies in physiology of vitamins; measurements of vitamin B requirement in several species of animals. *Am. J. Physiol.*, 1932, *101*, 115–139.
3. Cowgill, G. R. Physiology of vitamin B_1. *J. Am. M. Ass.*, 1938, *110*, 805–812.
4. Cowgill, G. R., Duel, H. L., Jr., Plummer, N. H., and Messer, F. C. Studies in physiology of vitamins; vitamin B in relation to gastric motility. *Am. J. Physiol.*, 1926, *77*, 389–401.
5. Elsom, K. O. Practical aspects of vitamin B deficiency. *Med. Clin. North America*, 1937, *21*, 1229–1244.
6. Findlay, G. M. Pellagra-like lesions associated with deficiency of vitamin B_2 in rat. *J. Path. & Bact.*, 1928, *31*, 353–364.
7. Gross, L. Effects of vitamin deficient diets on rats, with special reference to the motor functions of the intestinal tract in vivo and in vitro. *J. Path. & Bact.*, 1924, *27*, 27–50.
8. Hargreaves, F., Fletcher, A. A., and Dickson, W. H. Influence of diet on the motor and trophic functions of the colon in rats. *Tr. Roy. Soc. Canada* (Sect. V. Biol. sc.), 1931, *25*, 197–198.
9. Kantor, J. L. Roentgen diagnosis of idiopathic steatorrhea and allied conditions; practical value of the "moulage sign." Am. J. Roentgenol. & Rad. Therapy, 1939, *41*, 758–778.
10. Mackie, T. T., and Pound, R. E. Changes in gastro-intestinal tract in deficiency states, with special reference to small intestine. *J. Am. M. Ass.*, 1935, *104*, 613–618.
11. McCarrison, R. Some surgical aspects of faulty nutrition. *Brit. M. J.*, 1931, *1*, 966–971.
12. Mecray, P. M., Jr., Barden, R. P., and Ravdin, I. S. Nutritional edema: its effect on gastric emptying time before and after gastric operations. *Surgery*, 1937, *1*, 53–64.
13. Menville, L. J., Ané, J. N., and Blackberg, S. N. Fluoroscopic study of motility of gastro-intestinal tract of rats fed on a vitamin deficient diet. *Proc. Soc. Exper. Biol. & Med.*, 1930, *27*, 894–895.
14. Pendergrass, E. P., and Comroe, B. I. Roentgen study of gastro-intestinal tract in chronic idiopathic adult tetany. Am. J. Roentgenol. & Rad. Therapy, 1935, *33*, 647–656.
15. Pendergrass, E. P., Ravdin, I. S., Johnston, C. G., and Hodes, P. J. Studies of the small intestine; effect of foods and various pathologic states on gastric emptying and small intestinal pattern. *Radiology*, 1936, *26*, 651–662.
16. Ravdin, I. S., Pendergrass, E. P., Johnston, C. G., and Hodes, P. J. Effect of foodstuffs on emptying of normal and operated stomach and the small intestinal pattern. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 306–315.
17. Sebrell, W. H. Vitamins in relation to prevention and treatment of pellagra. *J. Am. M. Ass.*, 1938, *110*, 1665–1672.
18. Snell, A. M., and Camp, J. D. Chronic idiopathic steatorrhea; roentgenologic observations. *Arch. Int. Med.*, 1934, *53*, 615–629.

B_1 AVITAMINOSIS*

ROENTGENOLOGIC STUDIES OF GASTROINTESTINAL TRACT IN RATS ON VITAMIN B_1 DEFICIENCY DIETS

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SOME investigators are of the opinion that diminished intestinal motor activity results from partial deficiency of vitamin B_1. It has not always been possible to evaluate accurately the conclusions variously obtained from experimental and clinical studies on this subject because of the errors inherent in the unphysiologic methods of investigation. For this reason, we turned to a physiologic method to examine the gastrointestinal tract of the rat. We introduced directly into the stomach, after a sufficient interval of fasting, measured quantities of a water-barium meal after which serial studies of the gastrointestinal tract allowed interpretation of motor activity under conditions not complicated by technical factors difficult to appraise.

TECHNIQUE

We used healthy young rats ten to twenty weeks old weighing from 100 to 250 gm. The vitamin B_1 deficiency diet was a complete rat food mixture totally lacking in vitamin B_1 and prepared according to the method of Chase and Sherman.†[4] This diet, plus 5 gamma (γ) of vitamin B_1, was fed to the control group daily. All animals were weighed weekly and those that lost weight were observed daily and when it was evident death was near, they were sacrificed and necropsied. At the beginning of the experiment, all animals were studied roentgenographically. The test meal was a 3 cc. water suspension of barium sulphate put directly‡ into the stomach through a metal tube—a No. 20 gauge needle, 5 inches long, the point of which was filed down to form a rounded smooth opening (Fig. 3). While the animal was held supine with the head retracted, the tube (like a rigid gastroscope) was passed into the stomach and the test meal injected. In this way, the exact volume of our test meals was controlled. The animals were not allowed food or water for eighteen hours prior to the roentgen studies. Films were made at fifteen minutes, and one, two, three, four, five, six and twenty-four hours after injection of the meal. After the roentgen studies were begun, no food or water was given the animal until after the test meal had been evacuated from the stomach. Two or more standardization studies were made on all rats before they were placed on the vitamin B_1 deficiency diet.

RESULTS

As in humans, a variation was found in gastrointestinal motility in the 8 normal animals studied. The stomach usually emptied in two hours (a 3 cc. water-barium meal), but varied from one to three hours. The head of the column usually reached the cecum in four hours, but varied between three and five hours. The colon was usually emptied in twenty-four hours.

In the 8 rats on a vitamin B_1 deficiency diet, a decrease in gastrointestinal motility was apparent in one month in those fed a completely vitamin B_1 deficiency diet and a longer period in those fed diets only partially deficient in vitamin B_1. These observations were associated with varying grades of atonicity and dilatation of the entire gastrointestinal tract. The roentgenograms illustrated in Figure 1 show the effect of the vitamin B_1 deficient diet after two months. In Figure 2, a less pronounced effect is observed where the diet had been only partially deficient in Vitamin B_1.

† Obtained from the Harris Laboratories, New York City.
‡ We now use a thin rubber catheter with more success.

* From the Medical Research Laboratory, S. S. Fels Fund, Medical Tower, Philadelphia.

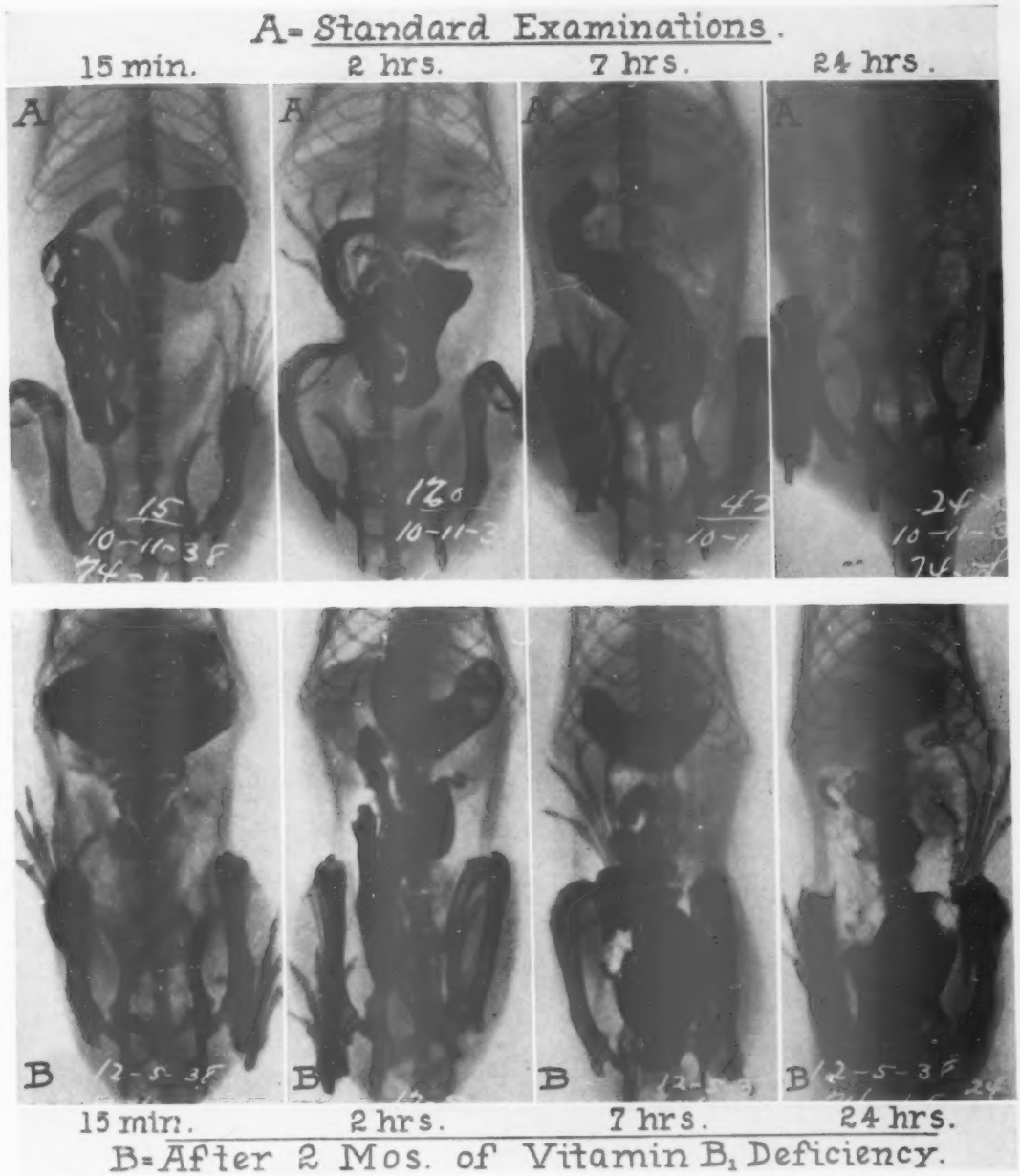
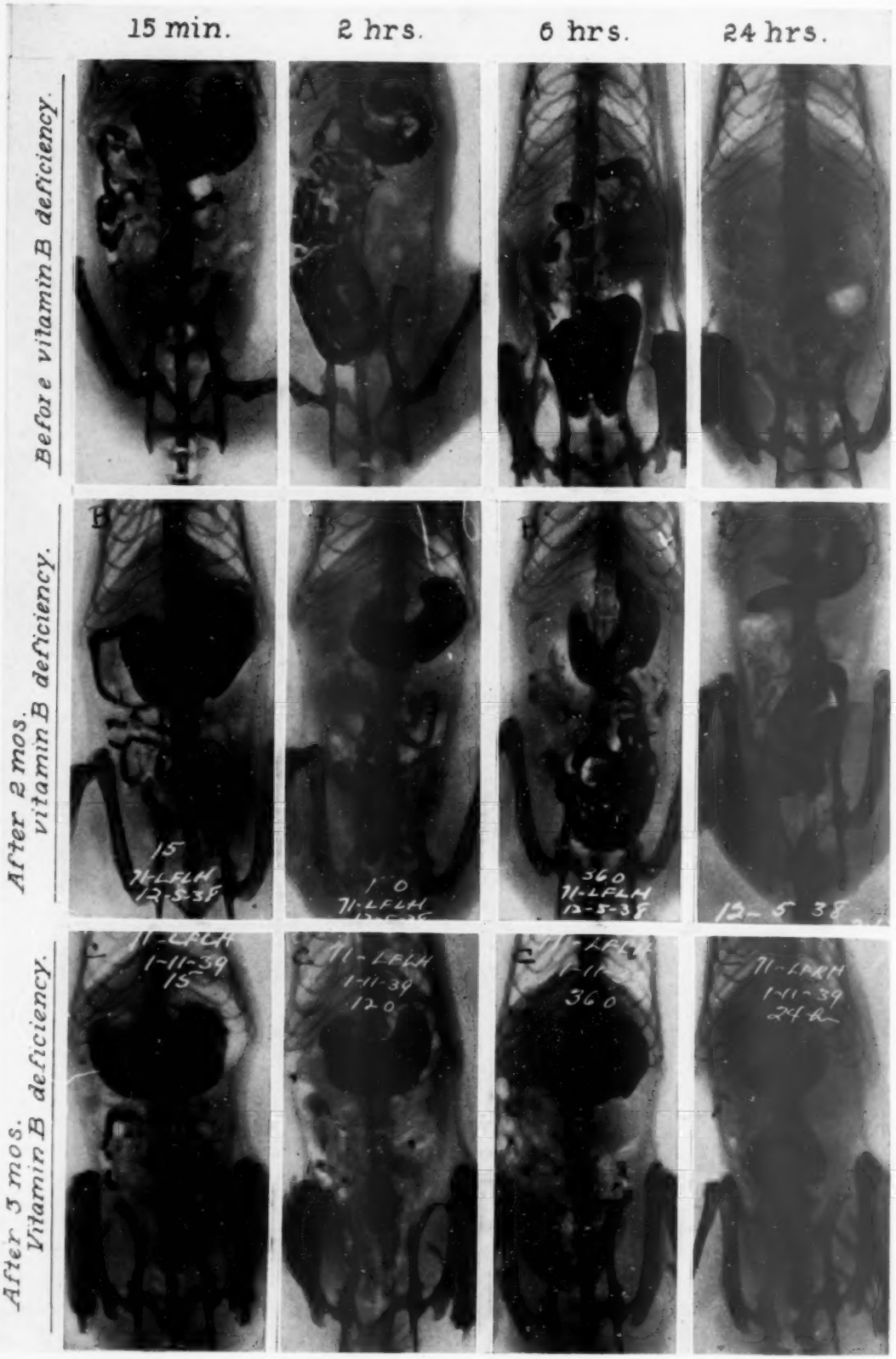


Fig. 1. Complete B_1 avitaminosis. *A*, these serial examinations in the normal control reveal gastric evacuation at the end of two hours, colon emptied in twenty-four hours. *B*, same animal two months later after having been on vitamin B_1 deficiency diet. The stomach and small intestine are dilated and hypotonic. Slight gastric residue present at twenty-four hours. Moderate colonic dilatation and stasis visible in twenty-four hour film.

DISCUSSION

Our studies were not a quantitative measure of anorexia, considered by Karr,[3] Sherman[4] and Cowgill[1] an important factor in the cause for changes in gastric motility resulting from vitamin B_1 deficiency diets. We did observe a decreased desire for food by our animals, however, and this could be adequately explained by the gastric atonicity and stasis roentgenographically ob-


15 min.
2 hrs.
6 hrs.
24 hrs.
Before vitamin B deficiency.
After 2 mos. vitamin B deficiency.
After 3 mos. Vitamin B deficiency.

served. Barium enema studies on rats done by Sparks and Collins[5] led them to believe that normal motility of the intestines was dependent on the presence of vitamin B_1, but some question may have been raised concerning their interpretation because the work of Hargreaves, Fletcher and Dickson.[2]

Since the deficiency diets we used were lacking only in vitamin B_1, there is reason to believe that this is the fraction of yeast, wheat germ and various other concentrates of vitamin B that accounts for the motor

Fig. 3. Needle shown in place in stomach after having been passed through esophagus. A 3 cc. water-barium meal had been injected just prior to the making of this roentgenogram.

barium enema examination is regarded by some as unphysiologic. Our use of the progress meal method, considered physiologic by most investigators, confirms the conclusions of Sparks and Collins. Dilatation of the colon, anatomically present following vitamin B_1 deficiency, as we observed it roentgenographically, is confirmed by the changes observed in the gastrointestinal tract. Even partial deprivation of vitamin B_1 produced appreciable alterations in gastrointestinal motility. Therefore, it seems important enough to emphasize that there need be only a moderate lack of vitamin B_1 over a sufficient period to produce demonstrable changes in motor activity of the

Fig. 2. Partial B_1 avitaminosis (about one-third normal). *A*, serial examination during control period. The stomach is empty in two hours and the colon in twenty-four hours. *B*, after two months on diet of partial vitamin B_1 deficiency (0.5 unit daily), gastric retention is present at end of twenty-four hours. There are dilatation, hypotonicity and stasis of the entire gastrointestinal tract. *C*, one month later, hypotonicity, dilatation and stasis of gastrointestinal tract have increased.

FIG. 4. *A*, serial examinations of on a rat full normal diet. *B*, similar examinations repeated six weeks later on same rat which had been allowed only 25 per cent of the normal diet. This animal lost weight from 212 to 160 gm., but no appreciable effects were noted in the tone or motor activity of the gastrointestinal tract.

alimentary tract. In those animals on 1.5 gamma of vitamin B_1 daily (the normal requirements being estimated at about 12 gamma), roentgenographic alterations in gastrointestinal motility were observed in a very short time.

All animals on the vitamin B_1 deficiency diets lost weight; the more deficient the diet in vitamin B_1, the more rapid the loss of weight; and, similarly, the greater the gastrointestinal atonicity, stasis and dilatation. Consequently the question of the relationship of inanition to the effect on intestinal motility was raised. From the work of Sure and Thatcher,[6] there was reason to expect that the effect was related to vitamin B_1 deficiency rather than to undernutrition because of insufficient food intake.

To confirm this, 5 adult Wistar rats in good health were used, weighing from 163 to 360 gm. at the beginning of the experiment. Control serial roentgen examinations of the gastrointestinal tract were made as in the vitamin B_1 deficiency studies. The rats were then placed on a starvation diet, the constituents being the same as in the normal diet, but the quantity reduced to 25 per cent of normal; that is, 5 gm. of food were given daily to each rat instead of 20 gm., the normal ration. Water intake was not limited. The animals were then weighed twice weekly and, at the end of a month, they all had lost weight ranging from 39.2 to 155 gm. Roentgen examinations, similar to those made in the beginning, were then repeated. A sample of the findings is shown in Figure 4. During the second month of the experiment, 4 of the 5 animals died of inanition.

The comparative roentgen examinations did not reveal the same effects on the gastrointestinal tract by the starvation as by the vitamin B_1 deficient diet. While there was apparently some lack of tonicity of the stomach and colon, it seemed commensurate with the general emaciated state of the animal.

CONCLUSIONS

(1) Gastrointestinal hypotonicity, dilatation, and stasis were found to follow vitamin B_1 deficiency; the greater the deficiency, the more pronounced were the anatomical and motor changes.

(2) A water-barium meal was used to study gastrointestinal motor activity in the rat. The test meal was introduced directly into the stomach after an eighteen hour fast period.

(3) The findings of these experiments were limited to diets deficient only in vitamin B_1.

(4) The changes in gastrointestinal tone and motility observed in animals fed a vitamin B_1 deficient diet are not accounted for by the mere loss of weight which occurs in these animals.

REFERENCES

1. COWGILL, G. R. Contribution to the study of the relation between vitamin B and the nutrition of the dog. *Am. J. Physiol.*, 1921, *57*, 420.
2. HARGREAVES, F., FLETCHER, A. A., and DICKSON, W. H. Influence of diet on motor and trophic functions of colon in rats. *Tr. Roy. Soc. Canada* (Sect. V. Biol. sc.), 1931, *25*, 197–198.
3. KARR, W. G. Some effects of water-soluble vitamin upon nutrition. *J. Biol. Chem.*, 1920, *44*, 255.
4. SHERMAN, H. C. Food and Health. The Macmillan Co., New York, 1934.
5. SPARKS, M. I., and COLLINS, E. N. Role of vitamin B_1 in tonus of the large intestine. *Am. J. Digest. Dis. & Nutrition*, 1935, *2*, 618–620.
6. SURE, B., and THATCHER, H. S. Avitaminosis. *Arch. Path.*, 1933, *16*, 809–816.

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EDITORIAL

THE NECESSITY OF A COORDINATED BIOLOGICAL DOSE SYSTEM IN RADIATION THERAPY

FOR some time the impression prevailed that the introduction of a biological unit, parallel to the r, would aid to overcome many of the difficulties encountered in clinical dosimetry of radiation. Since the tolerance and damage of the skin form the most important criteria of biological effectiveness in any form of irradiation, and since for the present no other useful biological indicator is in sight, it appeared best to make a certain level of the cutaneous reaction the basis of a biological standard. Epilation dose, threshold erythema dose, skin erythema dose, tolerance dose, etc., are examples of such possible standards.

In 1937, it was suggested in an editorial in this JOURNAL[1] to choose any one of these standards as, for example, the "skin erythema dose" (S.E.D.) and to give it a physical meaning. By thus proceeding it would be possible, with the help of clinical experience, to establish the magnitude, expressed in r, of the standard S.E.D for all qualities of radiation, including the gamma rays of radium. The calculated curve of Lauritsen[2] relating the approximate erythema to the monochromatic equivalent voltage up to 900 kv. was recommended as the starting point.

Since then several new observations have been made, chiefly in connection with the clinical application of the supervoltage roentgen rays and the standardization in r of the gamma rays of radium. As these observations furnish additional proof for the necessity of a coordinated biological dosage system, they will be discussed below.

(1) With increasing voltages a gradually larger physical dose can be administered to produce the same skin erythema. This fact was already known, but the extension of the therapeutic voltage range up to 2,000 kv. and down to 40 kv. made it more evident. It was noted that a difference of more than 500 per cent exists between these two extremes. Thus whereas at 40 kv. (peak) an erythema is obtained with 200 r or less, above 1,000 kv. it takes more than 1,000 r to produce the same degree of erythema. Obviously, the simple summing up of the number of r given, when rays of more than one quality are used, makes the dosage meaningless even if all physical factors pertaining to the technique of the irradiation are specified. Two hypothetical examples will illustrate the point. A cancer of the bladder is treated by a combination of external supervoltage (1,000 kv.) and intravesical low voltage (60 kv.) roentgen therapy, the total tumor dose (D_t) amounting to 4,000 r. The former is carried out in three weeks' protraction with a tumor dose (D_{10}) of 2,000 r and the latter through cystotomy in one seance likewise with a tumor dose (D_0) of 2,000 r. Or, a cancer of the cervix is irradiated by association of external deep roentgen therapy (200 kv.) and intracavitary radium, again with a total tumor dose (D_t) of 4,000 r. Here, too, the external irradiation is carried out in three weeks' protraction with a tumor dose (D_{12}) of 2,000 r and the intracavitary radium is left in situ over forty-eight hours for a tumor dose (D_0) of 2,000 r. Thus, although the physical dose in both cases

[1] Physical and biological dosage in radiation therapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 367–369.

[2] Lauritsen, C. C. Energy considerations in high voltage therapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *30*, 380–387; also, Energy considerations in medium and high voltage therapy. *Ibid.*, 529–532.

would seem to indicate similar numerical values, the problem assumes quite a different aspect when the biological equivalence is analyzed. In the first case the 4,000 r corresponds approximately to 130 per cent +1,000 per cent = 1,130 per cent skin erythema dose and in the second to 150 per cent + 190 per cent = 340 per cent skin erythema dose.

Since such great variation may occur with different voltages, it is important that the quality of the radiation be expressed in a clinically convenient and uniform manner. The ideal thing would be to make use of the equivalent voltage necessary to produce monochromatic radiation. This is determined by measuring in terms of half-value layer the attenuation of the roentgen beam in water which nearly parallels absorption conditions of the human body[2] or in some light element, as, for example, aluminum.[3] The equivalent voltage permits the plotting of a curve relating accurately measured physical doses to the skin erythema. The International Committee on Radiological Units[4] at its last meeting in 1937 in Chicago recommended that for medical purposes the quality of the roentgen radiation be expressed in half-value layer of the following material: cellophane or cellone up to 20 kv. (peak); aluminum for 20–120 kv. (peak); copper for 120–400 kv. (peak) and tin above 400 kv. (peak). Since then lead has been advocated by many above 700 kv. (peak). In clinical practice, however, the statement of the applied voltage (and forefilter) still represents the simplest method of radiation quality specification. Inasmuch as at higher levels considerable difference in the quality of the rays may result from the various voltage forms, it is desirable that, unless the monochromatic equivalent is used, the wave form also be stated by always indicating whether the potential is constant, pulsating, peak or some other type. If this is not done, discrepancies in the biological reactions, especially cutaneous erythema, may be expected. A 1,000 kv. pulsating radiation, for example, is equivalent to approximately 600 kv. monochromatic radiation so that the difference in the physical dose necessary to produce a similar erythema may amount to 200 r, all other factors remaining identical.

(2) The spatial distribution of the radiation at higher voltages also assumes such proportions that at the same applied voltage a variation in the biological effect with azimuthal angle between 0° and 90° is obtained due to change in quality of the roentgen beam. It has been demonstrated by Corrigan, Cassen and Hayden[5] that if a vanishingly thin or so-called transparent target is used in a supervoltage tube, the hardest radiation emerges in the forward direction at a characteristic angle with respect to the cathode ray. From this point there is a gradual falling off both toward the 0° axis and toward the larger angles. At an applied voltage of 500 kv. constant, for example, the variation of quality with azimuthal angle between 0° and 90° leads to a difference of the order of 100 kv. equivalent voltage. In a non-transparent thick target there is an addition of softer rays from the impingement of the electrons on the successive layers of the target as well as from the emission of radiation characteristic of the target material, so that here the difference appears still greater.

From the clinical standpoint, this means that if a supervoltage roentgen therapy tube is provided with more than one portal for the simultaneous treatment of several patients, the skin reaction of the various portals may show a difference in degree, notwithstanding the fact that the applied voltage is the same and all physical factors, including the intensity rate, are absolutely

[3] Leucutia, T., and Corrigan, K. E. Present status of roentgen therapy with voltages above 200 kv. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 628–662.

[4] Recommendations of the International Committee for Radiological Units (Chicago, 1937). Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 295–298; also *Radiology*, 1937, *29*, 634–636.

[5] Corrigan, K. E., and Cassen, B. Spatial distribution of radiation from a supervoltage roentgen tube and its significance in therapy. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 811–818; also Corrigan, K. E., Cassen, B., and Hayden, Henrietta S. Spatial distribution of radiation from a supervoltage roentgen tube. II. Am. J. Roentgenol. & Rad. Therapy, 1938, *39*, 634–640.

identical. The lowest erythema will always appear at the end of the tube corresponding to the cone of the characteristic angle around the geometric projection of the axis of the electron beam and from here it will increase toward the larger angles, that is, the side portals. In the above mentioned range a difference of an erythema equivalent to 100–200 r may exist between a portal at 0° and 90°, with the filters commonly used in therapy. Of course, if the roentgen tube is provided with a thick target and the radiation is taken out at 45° angle, the erythema equivalence may assume in comparison even higher values.

This variation of the biological effect of the radiation with azimuthal angle of emission indicates that the statement of the applied voltage (and forefilters), even if accompanied with a description of the target material and the plotting of the isotropic distribution, does not specify the radiation quality as satisfactorily as the determination of the equivalent voltage.

(3) Another factor which produces a variation of the biological effectiveness of a given physical dose of radiation at higher voltages is the change in depth of the equilibrium level of the roentgen rays (or gamma rays of radium) with their secondary electrons. Failla, Twombly and Marinelli[6] have shown that a roentgen- (or gamma-) ray beam used for therapy reaches the skin containing, apart from the electrons emitted by the filters, cones, etc., a certain number of high speed secondary electrons originating from a collision of the rays with the gas molecules which they meet in traversing the air. When such a beam enters the skin it gradually acquires a much larger proportion of secondary electrons from the action of the rays upon atoms of the tissues, until at certain depth an equilibrium is produced consistent with the physical characteristics of the radiation and the medium. It was found that with 200 kv. (peak) radiation the equilibrium level lies within fractions of a millimeter from the surface of the skin, that is, in that layer of the corium which is responsible for the production of the erythema. Therefore, here, the phenomenon assumes no biological significance. However, at 1,000 kv. (pulsating), for example, the level is at a depth of 1.5 mm. and thus the cells above this layer undergo a subnormal degree of ionization with the result that the erythema will appear somewhat less pronounced. As may be seen, the depth of the equilibrium is a function of the penetration range of the secondary electrons, which in turn depends on the quality of the primary radiation.

Recently Quimby and Focht,[7] in a series of experiments, irradiated the skin with equal doses of 1,000 kv. (pulsating) radiation, but by covering half of the field with enough organic material (rubber dam) to bring the equilibrium level as close to the surface of the skin as possible. They found that the cutaneous reaction on the covered part was always more definite than on the exposed part, thus confirming the observations of Failla, Twombly and Marinelli.

The clinical implication of the effect of change in the ionization compensation with variation of voltage is that the higher the voltage, the deeper the equilibrium level and consequently the less the degree of erythema produced with the same physical dose (number of r). For the same reason, when treating with supervoltage roentgen rays, the skin should never be covered with any sort of material and the pressure cones, or other forms of diaphragms, should be substituted with open portals.

(4) The International Committee for Radiological Units, at its last meeting in Chicago, recommended that the dose of gamma rays of radium be also expressed in the unit r. Since then numerous attempts have been made to follow these recommendations in all radium treatment situations

[6] Failla, G., Twombly, G., and Marinelli, L. D. A method for decreasing the ionization in the skin applicable to supervoltage x-ray therapy. *Radiology*, 1937, *28*, 693–703.

[7] Quimby, Edith H., and Focht, Elizabeth F. Preliminary studies on dosage measurements with million volt roentgen rays. Am. J. Roentgenol. & Rad. Therapy, 1941, *46*, 376–399.

but soon it was discovered that the problem entails great difficulties. Mayneord and Honeyburne,[8] for example, found that, in intracavitary radium therapy, points only a few millimeters apart vary considerably in dose and that a change of position of only 1 mm. of a radium tube may result in a difference of 100 per cent in the dosage at a certain point. In interstitial radium application, the inaccuracies are even greater. Therefore, the physical doses measured or directly calculated close to the radium source represent gross approximations at the best.

Various other procedures were devised which would make the expression of the radium dosage in r conform more to actual clinical arrangements. Graphic methods of interpolation from isodose curves, complete volume distribution models, isodose contour diagrams through certain selected critical points, etc., are a few of these procedures. However, as shown by Quimby,[9] in the Janeway Memorial Lecture of 1940, even so some difficulties are encountered. For one thing, not the same value as expressed in r is correct for interstitial implants or external surface applicators and teleradium therapy, unless in this latter the skin is deliberately covered by a 4 mm. sheet of bakelite, celluloid, rubber, etc. (the thickness of the measuring ionization chamber wall). For another, although 1 r of gamma rays produces the same number of ions per unit mass of air as 1 r of roentgen rays, the same effect is not true for the skin or other tissues. Quimby, from a coordination of all available data, arrived at the conclusion that the amount of gamma radiation necessary to produce a threshold erythema of the skin corresponds to an average of 1,060 r. For this reason the simple addition of roentgen-ray r and gamma-ray r, as done for the specification of the physical dose, when a combination of the two therapeutic agents is used, cannot be expected to express correctly the tissue dose or the erythema dose. To avoid confusion, the Standardization Committee of the American Radium Society more recently[10] recommended that the symbol γ be affixed as subscript to the letter r whenever expressing gamma-ray dosage (r_γ).

(5) Some time ago Quimby and Pack[11] observed that if irradiation is undertaken by an association of deep roentgen rays and gamma rays of radium, the cutaneous reaction is less marked with a combination of the two than with either alone. When equal parts of roentgen rays of 165 kv. constant and gamma rays obtained from two platinum tubes of 50 mg. radium each were administered conjointly, it took a combined dose of 133 per cent to produce a threshold erythema, whereas if either was used alone the same biological effect was secured with a dose of 100 per cent. For other qualities of radiation or ratios of combination the increase in the combined physical dose to produce identical erythema assumes different values. There is also the possibility that some similar behavior may occur when roentgen rays of various qualities as, for example, very soft and very hard rays, are used in the combination of the irradiation, although this phase has not been investigated as yet.

All of the observations enumerated in the foregoing paragraphs indicate that often it is exceedingly difficult to try to base the clinical dosimetry of irradiation on physical methods alone. There can be no doubt that the introduction of the r as a fundamental unit of measurement for roentgen rays of various qualities as well as for gamma rays of radium has contributed to the solution of innumerable problems. But in many instances the dosage will not appear entirely clear until it is

[8] Mayneord, W. V., and Honeyburne, J. Physical study of intracavitary radium therapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *45*, 235–249.

[9] Quimby, E. H. The specification of dosage in radium therapy (Janeway Lecture, 1940). AM. J. ROENTGENOL. & RAD. THERAPY, 1941, *45*, 1–16.

[10] Report of the Research and Standardization Committee of the American Radium Society. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *43*, 118–125.

[11] Quimby, Edith H., and Pack, G. T. Skin erythema for combinations of gamma and roentgen rays. *Radiology*, 1929, *13*, 306–312.

stated also in terms of some biological standard.

The introduction of the "skin erythema dose" as a parallel biological unit, therefore, is of decided advantage. To eliminate the impression of inconsistency so often associated with skin reactions, it may be advisable to call it "skin unit dose" and designate it with the symbol S.U.D. As a matter of fact, the unit in the sense of the above meaning does possess a physical value, measurable in r, the magnitude of which changes with various voltages. The next step would be its standardization. On the basis of gathered clinical experience, the average number of r necessary to produce 1 S.U.D. under well defined conditions could be established along the entire voltage scale used in clinical therapy. As already stated, the voltage—to express comparable situations—is best specified in terms of monochromatic radiation. If the half-value layer determinations of the International Committee for Radiological Units are used for the quality measurement, these could be translated into terms of equivalent voltage, or vice versa.

It is to be hoped that a correlation of the physical and biological dosage will be accomplished in the near future and that as a result of this a uniform system of clinical dosimetry will be made available.

T. Leucutia

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual Meeting: Atlantic City, N. J., Oct. 6–9, 1942.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Annual meeting: Atlantic City, N. J., June 10, 1942.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Atlantic City, N. J., June 8–12, 1942.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Fairmont Hotel, San Francisco, Calif., Nov. 30–Dec. 5, 1941.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION
Secretary, Dr. J. D. Coate, 434 Thirtieth St., Oakland, Calif.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets bi-monthly on second Thursday, at place selected by Secretary. Annual meeting in May.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. SOC.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. Leo Harrington, 880 Ocean Ave., Brooklyn, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. C. J. Challenger, 3117 Logan Blvd. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, J. O. Newton, 13921 Terrace Rd., East Cleveland. Meets at 6:30 P.M. at Midday Club on fourth Monday each month, October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. Edward J. Meister, 366 Metropolitan Bldg., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Walter A. Weed, 204 Exchange Bldg., Orlando, Florida. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. H. C. Ochsner, Methodist Hospital, Indianapolis. Meeting held the second Sunday in May annually.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in April.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society meeting. Next meeting New Orleans, April, 1942.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. J. E. Lofstrom, 1536 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Hugh F. Hare, Lahey, Clinic, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. H. J. Perlberg, 921 Bergen Ave., Jersey City. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. Paul C. Swenson, Presbyterian Hospital, New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

NORTH DAKOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati. Meets at time and place of annual meeting of Ohio State Medical Association.

PACIFIC ROENTGEN SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave. Meets second Wednesday each month, 4:30 P.M., October to June, Pittsburgh Academy of Medicine.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St. Meets on second Thursday from October to May, inclusive. 8 P.M., Rochester Academy of Medicine Building.

Rocky Mountain Radiological Society
Secretary, Dr. A. M. Popma, 220 N. First St., Boise, Idaho, Annual meeting in Denver, summer of 1942.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. H. A. Hill, 450 Sutter St., San Francisco. Meets monthly on third Thursday at 7:45 P.M., first six months at Toland Hall, second at Lane Hall.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. L. W. Baird, Scott and White Clinic, Temple, Texas. Next annual meeting, Houston, Texas, February 7, 1942.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. C. H. Peterson, 603 Medical Arts Bldg., Roanoke, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. K. J. Holtz, American Bank Bldg., Seattle. Meets fourth Monday each month, College Club, Seattle.

X-ray Study Club of San Francisco
Secretary, Dr. J. M. Robinson, University of California Hospital. Meets monthly in evening on third Thursday.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 32 Welbeck St., London, W. 1 England.

Section of Radiology and Medical Electricity, Australasian Medical Congress.
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg. Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse Biel. Meets annually in different cities.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 P.M.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

EASTERN CONFERENCE OF RADIOLOGISTS

The Eastern Conference of Radiologists will be held in New York City on Friday and Saturday, January 23 and 24, 1942. Headquarters for the meeting will be the Biltmore Hotel. The registration fee of $5.00 includes luncheon and banquet tickets. Further information may be obtained from the Secretary, Dr. Paul C. Swenson, Presbyterian Hospital, New York City. The program of the meeting is as follows:

Scientific Program

Friday, January 23, 1942—9 A.M.

Diagnostic Section

Chairman—Ross Golden, M.D.

(1) Roentgenography of Exophthalmos. Raymond L. Pfeiffer, M.D., New York.
(2) Biochemical Aids to Roentgenological Problems in the Differential Diagnosis of Bone Disease. Alexander B. Gutman, M.D., New York.
(3) Toxoplasmosis in Infancy. Abner Wolf, M.D., David Cowan, M.D., and Cornelius G. Dyke, M.D., New York.
(4) Neurofibromatosis of Bone. Murray M. Friedman, M.D., New York.

RECESS: 10.30 to 10.45 A.M.

10.45 A.M.

Therapy Section

Chairman—Maurice Lenz, M.D.

(1) Radiotherapy of Tumors of the Brain. Cornelius G. Dyke, M.D., and Leo M. Davidoff, M.D., New York. Discussion: John R. Carty, M.D.
(2) Roentgen Therapy of Keloids. Arthur F. Hunter, M.D., New York. Discussion: Jerome P. Webster, M.D.
(3) Roentgen Therapy of Tuberculosis of Lymph Nodes. Maurice Lenz, M.D., Haig H. Kasabach, M.D., and C. William Chang, M.D., Discussion: John M. Hanford, M.D.
(4) Lymphosarcoma in Children. William E. Howes, M.D., Brooklyn, N. Y. Discussion: Samuel Richman, M.D.

LUNCHEON

Friday, January 23, 1942—2.15 P.M.

Diagnostic Section

Chairman—Ramsay Spillman, M.D.

(1) Post-traumatic Necrosis of Bone. Raymond W. Lewis, M.D., New York.
(2) Osteoid Osteoma. Maurice M. Pomeranz, M.D., New York.
(3) Incidence of Caisson Disease in Compressed Air Workers. A. L. L. Bell, M.D., George Edson, M.D., and N. Hornick, M.D., Brooklyn, N. Y.
(4) Radiology in Army Recruits. David E. Ehrlich, M.D., New York.
(5) Roentgenologic Observations during the Treatment of Club Feet. John P. Stump, M.D., New York.

RECESS

3.30 P.M.

Therapy Section

Chairman—William Harris, M.D.

Symposium on Radiation Injuries in the Treatment of Cancer of the Cervix.
Paper on Symposium: William Harris, M.D., Sidney M. Silverstone, M.D., and C. B. Braestrup, New York.
Discussion: Edith H. Quimby, M.S., Sc.D., James A. Corscaden, M.D., Nelson B. Sackett, M.D., Ira I. Kaplan, M.D., and William P. Healy, M.D.

7.15 P.M.

Banquet

Saturday, January 24, 1942—9.00 A.M.

Diagnostic Section

Chairman—Marcy L. Sussman, M.D.

(1) Ulcerative Colitis.
  1. Indications for Surgical Treatment. Moore A. Mills, M.D., New York.
  2. Roentgenologic Findings before and after Surgical Treatment. William H. Boone, M.D., New York.
(2) Diffuse Jejuno-ileitis. Marcy L. Sussman, M.D., and Emanuel Wachtel, M.D., New York.
(3) Circumscribed Mediastinal Neoplasms. Harold Neuhof, M.D., New York.
(4) Renal Osteitis. Maxwell H. Poppel, M.D., New York.

RECESS

10.45 A.M.

Therapy Section

Chairman—Douglas Quick, M.D.

(1) Radioactive Phosphorus as a Therapeutic Agent in Malignant Neoplastic Disease. John M. Kenney, M.D., New York. Discussion: Lloyd F. Craver, M.D.

(2) Recent Studies in the Production of Cancer by Chemical Compounds. Cornelius P. Rhoads, M.D., New York.

To the Editor:

My attention has been directed to the use of the word "dissemination" in the report of my discussion of the paper of Dr. George M. Wyatt and Dr. Sidney Farber, entitled Neuroblastoma Sympatheticum which was published in the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY, October, 1941, page 496. I did not wish to imply that the neoplastic growth was disseminated but that it was disintegrated by radiation therapy.

Therefore, I wish to substitute the word "disintegration" for "dissemination" and thus correct an unfortunate error which if allowed to stand as written would indicate that I subscribed to the theory that radiation therapy disseminated a neoplasm.

RALPH S. BROMER

PANEL DISCUSSION ON CARCINOMA OF THE BREAST

The Panel Discussion on Carcinoma of the Breast which was part of the Instruction Courses at the Cincinnati meeting was enthusiastically received. There were many requests to have mimeographed copies of this discussion. The following participated:

E. P. Pendergrass, M.D., Philadelphia, Pennsylvania, Director.

S. W. Harrington, M.D., Rochester, Minnesota.

Mont R. Reid, M.D., Cincinnati, Ohio

Maurice Lenz, M.D., New York City

Frederick W. O'Brien, M.D., Boston, Massachusetts

Charles L. Martin, M.D., Dallas, Texas

Harriet C. McIntosh, M.D., New York City

H. H. Bowing, M.D., Rochester, Minnesota

C. D. Haagensen, M.D., New York City

Varying opinions were expressed. The stenographer's report is necessarily rather long, but each author will edit his remarks and the proceedings of the Panel Discussion will be available at $2.50 per copy. It will be necessary to take advance orders in order to determine how many copies to have made up. Those wishing copies should send check and order to B. R. Kirklin, M.D., Mayo Clinic, Rochester, Minnesota, immediately. Make check payable to American Roentgen Ray Society, Section on Instruction.

AMERICAN BOARD OF RADIOLOGY

The following is a list of those who have been certified or granted additional certification during 1941:

1. Anderson, Charles Watson, Camp Polk, La., Radiology
2. Anderson, Johnson Rose, Shreveport, La., Roentgenology
3. Anthony, Benjamin W., Chicago, Ill., Radiology
4. *Ashbury, Howard Hicks, Baltimore, Md., Radiology
5. Attwood, Cyril John, Oakland, Calif., Radiology
6. Baender, Eric, Freeport, L. I., N. Y., Radiology
7. Baeyer, Eric Von, Cleveland, Ohio, Roentgenology
8. Baker, Sol Ronald, Los Angeles, Calif., Therapeutic Radiology
9. Beck, John, New York, N. Y., Radiology
10. Benzing, George, Jr., Cincinnati, Ohio, Diagnostic Roentgenology
11. Bierman, Morris, I., Washington, D. C., Diagnostic Roentgenology
12. Bouchard, Jean, Montreal, Quebec, Canada, Radiology
13. Boyd, Robert Wallace, Calgary, Alberta, Canada, Radiology
14. Boyer, Richard C., Chicago, Ill. (now at Fort Bliss, Texas), Radiology
15. Brackin, John T., Jr., Youngstown, Ohio, Radiology
16. Breimer, Charles W., New York, N. Y., Diagnostic Roentgenology
17. Bristow, Louis Judson, Jr., New Orleans, La., Radiology
18. Brock, Ernest H., New Orleans, La., Diagnostic Roentgenology
19. Brogan, Austin John, Dayton, Ohio, Diagnostic Roentgenology
20. Brown, Walter Earl, Schenectady, N. Y., Radiology
21. Bruder, Victor F. J., Winona, Minn., Radiology
22. Bunce, James Walter, North Adams, Mass., Diagnostic Roentgenology
23. Buschke, Franz J., Seattle, Wash., Radiology
24. Buzaid, Louis L., Honolulu, T. H., Radiology
25. Campbell, John Alexander, Cincinnati, Ohio, Radiology
26. Campbell, Thomas Anthes, Philadelphia, Pa. (now at Fort Eustis, Va.), Radiology
27. Carrigan, Francis P., Newark, N. J., Roentgenology
28. Chalek, Jack I., Johnson City, N. Y., Radiology
29. Cawley, Frank Thomas, Washington, D. C., Radiology
30. Childs, Theron Baker, Evanston, Ill., Roentgenology
31. Clift, Myron William, Flint, Mich., Radiology
32. Cobbs, Lea A., Salem, Ohio, Roentgenology
33. Cohn, Harold Arnold, Vancouver, Wash., Radiology

* Additional certification.

34. Cooper, Wayne K., Iowa City, Iowa (now at Jefferson Barracks, Mo.), Radiology
35. Cosgrove, William James, Grand Rapids, Mich., Radiology
36. Cove, Arthur M., Fort Totten, N. Y., Radiology
37. Cowan, Leland R., Salt Lake City, Utah, Therapeutic Radiology
38. Crowder, Robert M., Albany, N. Y., Radiology
39. Culver, Gordon J., Buffalo, N. Y., Roentgenology
40. Dillman, Melvin A., Philadelphia, Pa., Radiology
41. Dougall, John Mac, Memphis, Tenn., Roentgenology
42. Duff, Alexander McGill, Jr., Philadelphia, Pa., Therapeutic Radiology
43. Eaglesham, Douglas Cameron, Montreal, Quebec, Canada, Roentgenology (now at No. 1 Neurological Hospital, Canadian Army Overseas)
44. Elkin, William Paul, Charleston, W. Va., Radiology
45. Faris, Hervey S., Tucson, Ariz., Roentgenology
46. Fetter, John S., Philadelphia, Pa., Radiology
47. Fleischner, Felix, Greenfield, Mass., Radiology
48. Foster, Frank Lloyd, Cranford, N. J., Diagnostic Roentgenology
49. Fox, Isar, Harlingen, Texas, Diagnostic Roentgenology
50. Francis, William Joseph, New York, N. Y., Diagnostic Roentgenology
51. Freedman, Lester M. Jules, Pittsburgh, Pa., Radiology
52. Friedell, Hymer L., New York, N. Y., Radiology
53. Frost, Earl J., Wichita, Kan., Diagnostic Roentgenology
54. Fullenlove, Thomas McLellan, San Francisco, Calif., Radiology
55. Ghiselin, Francis H., New York, N. Y., Diagnostic Roentgenology
56. Glickman, L. Grant, Minneapolis, Minn., Diagnostic Roentgenology
57. Godfrey, Ellwood Watson, Philadelphia, Pa., Radiology
58. Goehring, Harrison D., Boston, Mass., Roentgenology
59. Goss, Erich, Woodside, L. I., N. Y., Diagnostic Roentgenology
60. Greenidge, Robert, Detroit, Mich., Diagnostic Roentgenology
61. Grossman, Jack William, Chicago, Ill., Radiology
62. Hamilton, John Bland, Kingsport, Tenn., Roentgenology
63. Harvey, Rolfe Marsh, Bryn Mawr, Pa., Radiology
64. Haworth, James Blaine, Portland, Ore., Radiology
65. Heilbrun, Norman, Buffalo, N. Y., Roentgenology
66. *Held, Louis Arthur, Brooklyn, N. Y., Radiology
67. Hemminger, George W., Sacramento, Calif., Roentgenology
68. Hewes, Frederic Leo, Cleveland, Ohio, Radiology
69. Hiemstra, Wybren, Minneapolis, Minn., Radiology
70. Holleb, Eugene Milton, New York, N. Y. (now at Pine Camp, N. Y.), Radiology
71. Horwitz, Manuel, Providence, R. I., Radiology
72. Hsu, Chien Liang, Peking, China, Radiology
73. Huffman, John Francis, San Francisco, Calif., Roentgenology
74. Hughes, Charles Robert, Cleveland, Ohio, Roentgenology
75. Hurt, Floyd Kinzer, Lakeland, Fla., Roentgenology
76. Imboden, Henry Miles, Mt. Vernon, N. Y., Radiology
77. Imler, Allison Ellwood, Philadelphia, Pa., Therapeutic Radiology
78. Jacobs, Melville Leonard, Pasadena, Calif., Therapeutic Radiology
79. Kaighn, Charles B., Atlantic City, N. J., Roentgenology
80. Kibbe, Pressley A., New Orleans, La., Radiology
81. Klinefelter, Edmund William, York, Pa., Diagnostic Roentgenology
82. Kolker, Louis, New York, N. Y., Radiology
83. Kornblum, Daniel, Jackson Heights, L. I., N. Y., Radiology
84. Larson, Sidney, Rochester, N. Y., Radiology
85. Levi, Sam, New Orleans, La., Roentgenology
86. Levy, Jack Heymann, New York, N. Y., Radiology
87. Lipschutz, Isidore S., New York, N. Y., Radiology
88. Little, Edgar Hugh, New Orleans, La., Radiology
89. Long, Leonard, Bluffton, Ind., Radiology
90. McAneny, John Barry, Johnstown, Pa., Radiology
91. McCullough, John A., Rochester, Minn., Radiology
92. McDonald, Eugene Joseph, Boston, Mass. (now on U.S.S. *West Point*), Radiology
93. McDowell, John R., Lakewood, Ohio, Diagnostic Roentgenology
94. Marcovich, A. W., Paw Paw, Mich., Radiology
95. Mendel, Walter H., Haverstraw, N. Y., Diagnostic Roentgenology
96. Mershon, Harry F., Los Angeles, Calif., Therapeutic Radiology
97. Miller, Edith Irene, Petersburg, Va., Radiology
98. Miller, Ivan J., San Francisco, Calif., Radiology
99. Miller, S. Thomas, Philadelphia, Pa., Radiology
100. Moorehead, Matthew Talmadge, Endicott, N. Y., Radiology
101. Morton, Joseph L., Cleveland, Ohio, Radiology
102. Mueller, Hans Peter, Boston, Mass , Radiology
103. *Mueller, Wilbur Kenneth, St. Louis, Mo., Radiology
104. Nash, Leo A., Fargo, N. D., Radiology
105. Nitkin, Robert Lewis, Jamaica, L. I., N. Y., Radiology
106. Nolan, Charles Joseph, St. Louis, Mo., Radiology
107. Palmer, Marta S., Manteno, Ill., Diagnostic Roentgenology
108. Parsons, Philip Brower, Charlotte, N. C., Radiology
109. Pascucci, Lucien Michele, Springfield, Mo., Radiology
110. *Pettit, Roswell T., Ottawa, Ill., Radiology
111. Pickwick, Erskine R., Fitchburg, Mass., Radiology
112. Poplack, Samuel Lewis, Taunton, Mass., Diagnostic Roentgenology
113. Prentice, Donald D., Albany, N. Y., Diagnostic Roentgenology
114. Prickett, John A., Abington, Pa., Radiology
115. Pugh, David G., Rochester, Minn., Radiology
116. Quinn, William P., New York, N. Y., Radiology
117. Reavis, Charles William, Kinston, N. C., Radiology
118. Reingold, Morris, Quantico, Va., Diagnostic Roentgenology
119. Rivkin, Hyman, Far Rockaway, N. Y., Diagnostic Roentgenology
120. Ruby, Robert J., Waterbury, Conn., Radiology
121. Rudner, Nathan, Charleston, S. C., Radiology
122. Russell, Thomas G., St. Louis, Mo., Radiology
123. Saul, Walter, Orange, Calif., Roentgenology
124. Scarpellino, Louis, Kansas City, Mo., Radiology
125. Scatchard, G. Newton, Buffalo, N. Y., Roentgenology
126. Schmidt, Hilmar Reinhold, Petersburg, Va., Therapeutic Radiology
127. Schneider, Martin, Dallas, Texas, Radiology
128. Sell, Frederick William, Rahway, N. J., Diagnostic Roentgenology
129. Seltz, Herman, Mitchel Field, Long Island, N. Y., Radiology
130. Settle, John William, Jr., Baltimore, Md., Radiology
131. Shehadi, William Henry, Hanover, N. H., Radiology
132. Shelden, James Thomas, Rochester, Minn., Radiology
133. Sherman, Banjamin H., Hollywood, Calif., Therapeutic Radiology
134. Shinney, Arthur Paul, Everett, Mass., Diagnostic Roentgenology
135. Shull, Elliott C., Camden, N. J., Roentgenology
136. Silverman, Morris, Washington, D. C., Radiology
137. Silveus, Esther, Pittsburgh, Pa., Roentgenology
138. Singer, John Edward, Akron, Ohio, Radiology
139. Singer, Siegmund F., New Hampton, Iowa, Roentgenology
140. Siwinski, Arthur G., Baltimore, Md., Therapeutic Radiology
141. Slaser, William Johnson, Ann Arbor, Mich., Radiology
142. Slater, Max, Jackson Heights, L. I., N. Y., Roentgenology
143. Slobodin, Harry, Hines, Ill., Therapeutic Radiology
144. Sorrell, Lewis Edmond, Birmingham, Ala., Roentgenology
145. Stillwell, Harry C., Rahway, N. J., Diagnostic Roentgenology
146. Stork, Walter J., Houston, Texas, Radiology
147. Strax, Philip, New York, N. Y., Radiology
148. Sturr, Robert P., Philadelphia, Pa., Diagnostic Roentgenology

* Additional certification.

149. Tager, Stephen Nathaniel, New Rochelle, N. Y., Roentgenology
150. Tharp, George W., Knoxville, Tenn., Radiology
151. Thompson, Archibald W., Buffalo, N. Y., Diagnostic Roentgenology
152. Trask, Burton Warren, Camp Edwards, Falmouth, Mass., Diagnostic Roentgenology
153. Tucker, Dan, New York, N. Y., Roentgenology
154. Van Zwaluwenburg, Benjamin Reyer, Toledo, Ohio, Radiology
155. Vaughan, Charles Edward, Hamilton, Ontario, Canada, Radiology
156. Walker, Dora V. H., Great Falls, Mont., Roentgenology
157. Ward, Willis Alfred, Chicago, Ill., Diagnostic Roentgenology
158. Watterson, Kenneth Ward, Meadville, Pa., Radiology
159. Weber, Joseph G. S., Indianapolis, Ind., Radiology
160. Weir, Don C., St. Louis, Mo., Radiology
161. Weisman, Joseph Charles, South Ozone Park, N. Y., Diagnostic Roentgenology
162. Wessel, I. J., Philadelphia, Pa., Diagnostic Roentgenology
163. Wexler, Harry, Philadelphia, Pa., Diagnostic Roentgenology
164. Weyrauch, Helen B. S., San Francisco, Calif., Radiology
165. White, George, Wrentham, Mass., Radiology
166. Whiteleather, John E., Memphis, Tenn., Roentgenology
167. Wiklund, Folke Walfred, Boston, Mass., Roentgenology
168. Witten, Morris, Brooklyn, N. Y., Radiology
169. Woods, Harold Harrison, Topeka, Kan., Radiology
170. Yoelson, Irwin E., Cleveland, Ohio, Roentgenology
171. Young, Asa Dougal, Baltimore, Md., Radiology

AMERICAN BOARD OF RADIOLOGY

At a special meeting of the Board of Trustees of The American Board of Radiology, Article VIII of the By-laws of the Board was amended to read as follows:

ARTICLE VIII

Applicants for Certificates

Section 1. Method of Making Application. Applications for certificates shall be made to the Secretary upon a prescribed form. Each application shall be accompanied by a fee in such sum as the Board, from time to time, may fix. The application shall also be accompanied by an unmounted photograph of the applicant.

Section 2. Qualifications of Applicants. Each applicant for admission to the examination shall be required to present evidence that he has met the following standards:

A. General Qualifications.

1. Satisfactory moral and ethical standing in the profession.
2. A license to practice medicine in the state or county in which he resides.
3. Membership in The American Medical Association, or membership in such Canadian or other medical societies as are recognized for this purpose by the Council on Medical Education and Hospitals of The American Medical Association.* Except as herein provided, membership in other societies shall not be required.
4. That the applicant holds himself out to be a specialist in Radiology or one of its branches as defined under "Definitions," and that he devotes his time primarily and principally (at least 75 per cent) to the practice of Radiology or one of its branches.
5. That he is a citizen of the United States or Canada.** Candidates from other countries must be permanent residents of that country and native citizens thereof.**

B. General Professional Education.*

1. Graduation from a medical school recognized by the Council on Medical Education and Hospitals of The American Medical Association. If the applicant is a resident of the United States or one of its possessions and is a graduate of a medical school outside the United States or Canada he must have a certificate of The National Board of Medical Examiners.
2. Completion of an internship, preferably of the general rotating type, of not less than one year in a hospital approved by the same Council.

C. Special Training.* (Applicable to candidates who begin their training on or after January 1, 1942, and to all candidates who are to be examined after January 1, 1945.)

1. After the completion of the internship there shall be a period of special training in Radiology of not less than three years in clinics, hospitals or dispensaries recognized and approved by The American Board of Radiology and the Council on Medical Education and Hospitals of The American Medical Association as competent to provide a satisfactory training in Radiology. This period of specialized training shall include:
   a. Graduate training in pathology, radiation physics and radiobiology.

      A period of six months' full-time training in pathologic anatomy is recommended but where this is not possible to arrange the student, during his three-year training period may, by attending pathologic conferences, postmortem examinations and studying removed tissues, receive adequate training in pathology. It is recommended that radiation physics be taught by a combination of didactic lectures, practical examples, and direct clinical demonstrations.

* Note: In special instances and by unanimous consent of the Credentials Committee of the Board, these requirements may be modified.

** Note: In special instances and by unanimous consent of the Trustees of the Board, these requirements may be modified.

b. An active experience (residency) of not less than twenty-four months in an institution, the radiologic department of which is recognized and approved by The American Board of radiology and the Council on Medical Education and Hospitals of The American Medical Association as capable of providing satisfactory training.

By special permission of the Board all or part of this training may be obtained under the immediate preceptorship of a radiologist or group of radiologists recognized by The American Board of Radiology as offering appropriate facilities for this type of postgraduate experience. Or the Board will accept a combination of training as outlined in (a) and (b)—for example, one may take a graduate course, including the basic sciences, in an accredited graduate school for one year, a residency for one year, and a preceptorship for one year; or he may take a graduate course for one year plus either a residency or preceptorship for two years.

c. Examination in the basic sciences of Radiology as well as the clinical aspects thereof. These examinations should be given by the student's instructors in order to allow those responsible for his training to certify to the Board that he is adequately prepared.

NEW REGISTRY OF DIPLOMATES

The American Board of Radiology is having a new registry of its diplomates printed as of January, 1942. If there has been a recent change of address will the diplomates please advise the Secretary, Dr. B. R. Kirklin, Mayo Clinic, Rochester, Minnesota, immediately.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

MISCELLANEOUS

Lahm, W. Über Radiumdosierung. (Radium dosage.) *Strahlentherapie*, 1940, *68*, 206–220.

The dose (D) is the total amount of radium or roentgen irradiation given. The dose yield (DL) is the dose that becomes effective in a unit of time. Radium dosage can be calculated accurately. The so-called radium element concentration can be calculated from the content of the preparation in milligrams of radium element, its length and the distance from it to the object to be irradiated. For the unit of time (an hour) this is equivalent to the DL. As a result of years of experiment and observation curves have been worked out that show that there is a constant relationship between the DL and the erythema dose. As a result of the long-continued action of radium equal physical doses do not always have the same biological effects. The biological effect is dependent not on D but on DL. With increasing DL the erythema dose decreases. The normal erythema dose is about 450 mgh/cm. but only within narrow limits of DL. The cumulation of doses also depends on the DL. Tables and graphs are given showing these relationships.

The second part of the work deals with the practical application of radium to surface carcinomas and carcinomas of the uterus. Illustrations are given that explain the method of calculation.—*Audrey G. Morgan.*

du Mesnil de Rochemont, R. Die Dosenverteilung bei der Rotationsbestrahlung. (The distribution of dosage in rotating roentgen irradiation.) *Strahlentherapie*, 1940, *68*, 221–253.

The author describes and illustrates with diagrams the distribution of the irradiation when the rotation of the tube is around an axis parallel to the longitudinal axis of the body and when it is around an axis perpendicular to the longitudinal axis of the body. The latter form does not have any advantage over the former with regard to the deep action of the irradiation and still less with regard to the uniformity of the dose applied to the pathological focus. In pendulum irradiation with a rotation of 180° the deep action and the uniformity of the dose applied to the focus is less than that of rotation around an axis parallel to the axis of the body. If a uniform distribution of the dosage over the whole pathological focus to be irradiated is prized more highly than the use of as small a dose as possible, the only choice lies between crossfire therapy from many fields with a fixed tube and rotation treatment with the axis of rotation parallel to that of the body. The same dose at the focus can be borne as well with the rotation method as with the crossfire method with a fixed tube.

The advantages of rotatory treatment: the greatest possible homogeneity of the irradiation of the focus, the possibility of increasing the dose at the focus considerably above what it has been heretofore without making too great demands on the skin, and the relatively small dosage applied to the tissues outside the focus, so that recovery takes place more quickly and irreversible injuries can be definitely avoided, assure a wide field of usefulness for rotating therapy in the treatment of deep-seated lesions. —*Audrey G. Morgan.*

Williams, Marvin M. D. Milliammeter inaccuracy caused by control cabinet. *Radiology*, June, 1940, *34*, 691.

In calibrating a roentgen therapy machine it was found that the milliammeter in the aerial system read about 10 per cent higher than that on the control cabinet which was in the grounded circuit of the secondary of the high voltage transformer. The aerial milliammeter was checked and found correct while the one in the control cabinet was checked and found 10 per cent too low.

The control cabinet meter has a bakelite case and the top of the control cabinet in which the meter is mounted is of steel. The steel surrounding the meter acts as a shunt for the meter's magnet, thus reducing the strength of the magnetic field around the coil of the meter and causing the reading to be low. The effect seems to be constant. Some meters in metal cases were found to be affected by iron in the same way although the effect was much smaller than for meters in bakelite cases.

The operation of a tube at a few per cent

above its rated capacity may not do any serious harm, but it is possible that some meters might be so much affected that their readings would be more than 10 per cent low and the overload on the tube would reduce its life. Therefore the cause of any difference in the reading of the meter in the aerial system and that on the control cabinet should be investigated carefully. On some machines, depending on the type of rectification, the checking of the control cabinet meters would have to be done with an alternating current instead of with a battery.—*Audrey G. Morgan.*

Warren, S. Reid, Jr. Roentgenographic unsharpness of the shadow of a moving object—II. *Radiology*, June, 1940, *34*, 731–740.

The first paper on this subject was published in *Radiology*, April, 1937. This paper presents certain analytical and experimental results that have been obtained since then. Mathematical formulae and curves showing the results are given.—*Audrey G. Morgan.*

Reinhard, M. C., and Warner, S. G. A preliminary report of the effect of x-rays on a tumor of known genetic constitution. *Radiology*, April, 1940, *34*, 438–439.

This is a preliminary report of experiments made to determine the effect of radiation on the genetic constitution of a tumor. A tumor was used that had developed spontaneously in a mouse of a dilute brown stock. When this tumor was inoculated into the same strain it took in 100 per cent of the cases. When inoculated into mice of three other strains there were no takes at all.

This tumor was inoculated into dilute brown mice of the same strain as the one in which it had occurred, and after the tumors had developed they were irradiated. A dose of 1,200 to 1,500 r was sufficient to destroy these tumors. It was thought that a much smaller dose would destroy their genetic constitution. A dose of 100 r was selected. One week after the irradiation of the tumor in vivo it was removed and inoculated into 46 mice of the three tumor-resistant strains mentioned above. From these 46 inoculations there were 23 takes, or 50 per cent of positive results in strains that had previously reacted negatively. That is, as a result of irradiation some change had occurred that caused a specific tumor to become definitely non-specific.

A more detailed report of the work will be published later.—*Audrey G. Morgan.*

Wertz, Ernst. Über die Abhängigkeit der Röntgenstrahlenwirkung vom Quellungszustand der Gewebe, nach Untersuchungen an Gerstenkörnern. III. Teil. (The dependence of the effect of roentgen irradiation on the degree of swelling of the tissues, from examinations of barley grains. Part III.) *Strahlentherapie*, 1940, *67*, 700–711.

This is the third of a series of articles in which an exhaustive study is made of the action of roentgen rays on grain embryos and plants at different stages of their development. In this article graphs show the details of the action of the rays on the different parts of the embryo at different stages of development as the seed swells. The half-value doses decrease continuously with increasing water content of the grains. The relation between the half-value dose and the degree of injury is discussed, as well as the percentage number of cells injured in the different parts of the embryo at different stages of swelling. Different parts of the embryo are injured to different degrees. The roots were found to be more sensitive to irradiation than the coleoptiles and the first leaves, and this may be due to the fact that mitosis begins in them at an earlier stage of germination.—*Audrey G. Morgan.*

Thoraeus, R. Standard curves of the absorption of roentgen rays in aluminum and their employment for estimating the equivalent of the initial filtration in roentgen tubes. *Acta radiol.*, 1940, *21*, 603–614.

The total filtration of roentgen radiation is made up of the initial filtration through the tube wall or window and any absorbing layers in the tube and the additional filtration through special filters provided outside the tube. To speak of unfiltered radiation is not correct as there is necessarily some amount of initial filtration. This initial filtration should be known for each tube in order to be able to define filtration correctly. The author gives standard curves for the absorption of roentgen rays in aluminum, obtained at constant potential tube-voltages between 50 and 100 kilovolts by means of a standard air ionization chamber and a roentgen tube the wall of which is 0.2 mm. aluminum. On the basis of these curves a method is developed for determining the initial

filtration of any tube in millimeters of aluminum; it is illustrated by the results from nine other tubes.

In cases in which no additional filtration is used, the initial filtration of the tube or radiating unit must be given; otherwise the description of the technique will be very incomplete and serious mistakes may be made.—*Audrey G. Morgan.*

FRANCIS, TORBEN. Das Verhältnis der Belichtungszeit zur Spannung und Objektdicke in der Röntgenphotographie. (The relation of exposure time to voltage and size of object in roentgen photography.) *Acta radiol.*, 1940, *21*, 510–518.

The best basis on which to calculate exposure time in roentgen photography is the measurement of the object, provided this measurement is properly carried out. Milliampere-second curves are very useful in practical work and give very good results in the form of homogeneous and correctly exposed roentgenograms. The curves should allow for an ample margin in both directions—a reserve margin—if good results are to be obtained and individual variations in the objects neutralized. A considerable number of test exposures must be made in order to get good results. In using the curves the technique of measurement should be as accurate as possible and as well adapted to each projection. Measurement of the object gives the examiner a better understanding not only of the object itself but also of the proportion between exposure time, voltage and thickness of the object.—*Audrey G. Morgan.*

KAALUND-JØRGENSEN, OTTO. Experiments in transmission of leukoses from mice to roentgen-irradiated rats. *Acta radiol.*, 1940, *21*, 483–499.

The author thinks this study may be of value in experimental cancer research, for the transmissible mammalian leukoses are neoplastic in nature. It has so far proved impossible to transplant malignant tumors from one species of animal to another.

Rats were first irradiated with a roentgen dose of 570 to 625 r and inoculated immediately afterwards with mouse leukosis. This was successfully carried forward through 11 passages in rats. The disease could be transmitted back to mice. Undoubtedly leukemic changes were also found in two other rats in which leukemic mouse material had been implanted subcutaneously. He holds therefore that heterotransmission has been successfully accomplished.

But attempts to transmit to pre-irradiated rats three other mouse leukoses that had been highly specific in mice failed.

He attempts to explain the difference between the strains that took and those that gave negative results. The ones that gave positive results were old laboratory strains which had been carried forward for several years in mixed mouse material. They therefore had great growth energy from the first and the continued transmission for years had resulted in a selection of the cells that had the greatest growth energy. On the other hand, the tumors that had grown only in pure strains of mice had not undergone any such selective process.

Little is known in regard to what it is that makes heterologous growth of tumor cells possible. The author concludes that all that can be said with certainty is that the general irradiation of the body with roentgen rays causes paralysis of the reticulo-endothelial system and the reduction in white cells is a measure of the degree of the paralysis.—*Audrey G. Morgan.*

RUSS, S., and SCOTT, G. M. Radium and radon; biological reactions compared. *Lancet*, June 8, 1940, *1*, 1048.

The authors have previously reported on the effects of radium as manifested by exposures to the ovary of a rabbit. Since radium has been put into federal custody (in England) it is not now available as formerly and the question is presented as to the comparative effects by radon. Comparable radiation dosages were administered; the initial dose of radon was 6 millicuries and it was left in situ for 11.1 days (thereby being equivalent to 6 mg. of radium element applied for 4.8 days). Following such exposures, the rabbits were allowed to live for six weeks, then killed. Such studies were conducted with the use of filters of 0.6 mm. platinum and 0.3 mm. platinum. With filtration of 0.6 mm. platinum, the irradiation effects appeared to be the same for radon as compared with radium, whereas with 0.3 mm. platinum greater damage was produced with radon—"likely due to the filtration effect of the outer layers of the radium element with consideration of the radiation produced by the innermost layers of it."—*A. A. de Lorimier.*

Condon, E. U. Recent advances in nuclear physics. *Radiology*, May, 1940, *34*, 581–588.

The author traces the history of development of knowledge of the structure of the atom since 1912 when it was found that atoms are built on a plan resembling that of the solar system. There is a central nucleus surrounded by electrons. With the discovery of the wave movement of particles the study of the nucleus was stimulated and the discovery of the neutron in 1932 made a number of theoretical developments possible. It was found that when a target is bombarded with a particle the result is not one of the known elements but a new element, or more properly speaking, new isotopic forms of the old elements which are radioactive. All of the elements have been rendered radioactive in the past few years except some of the rare earths and that is because they have not been studied.

These artificial radioactive elements will certainly prove of importance in biological science in two ways. In the first place if they can be produced in large amounts they may be used as substitutes for radium. And they will perhaps be even more useful indirectly in the study of biochemical processes, using these artificial radioactive atoms as tracers. The course of a given amount of material in the body through various processes of metabolism can be followed by tracing the course of the radioactive material.

Further possibilities in this field are discussed, with the warning that it will take long and patient work to develop them to their fullest extent.—*Audrey G. Morgan.*

Tasca, Marco. Fissazione del Radon da parte di lipidi ex ovo emulsionati. (Fixation of radon by an emulsion of egg lipids.) *Radiol. med.*, Sept., 1940, *27*, 721–726.

The author describes experiments in determining the fixation of radon by a 5 per cent emulsion of lipids from eggs in physiological salt solution. He found that radon is strongly attracted by this finely emulsified lipid from egg yolk and that the amount fixed by it is forty times as great as the amount fixed by an equal volume of physiological salt solution. The fixation between lipids and radon is relatively stable, at least in a closed vessel. The radon leaves the lipids to which it is fixed very slowly. The affinity of radon for lipids has the character of selective absorption; that is, it diffuses toward these lipids much more rapidly than toward any other substances present in the emulsion. A further study will be made of the rapidity of diffusion of radon toward lipids and of the disintegration of the lipids within a few days by the action of radon in vitro.—*Audrey G. Morgan.*

Taylor, Lauriston S. The economic features of x-ray protection. *Radiology*, April, 1940, *34*, 425–437.

Basic rules for radium and roentgen-ray protection have been given by the International Commission on X-ray and Radium Protection and published in various journals. More detailed rules prepared in this country are available in N. B. S. Handbook 20 (X-ray Protection) and N. B. S. Handbook 23 (Radium Protection) which can be obtained from the Government Printing Office at Washington for ten cents each. These give rules for maximum protection and any errors will be on the safe side, but not necessarily the most economical one.

The author in this article gives tables and graphs giving lead protection under various conditions of voltage, etc., and calculations in regard to the cost of lead and various possible substitutes such as concrete blocks. He also gives calculations for protection against scattered radiation and protective tube enclosures and directions for the best location of tubes in treatment rooms.—*Audrey G. Morgan.*

Fricke, Robert E., and Williams, Marvin M. D. Radium protection: measurements of exposure to gamma rays. *Radiology*, May, 1940, *34*, 560–567.

The authors review the literature on the subject of protection of persons exposed to radium radiation and describe their own work at the Mayo Clinic in determining the safe limits of exposure to 2 gm. radium. They describe the ionization and photographic methods used. In the latter the darkening produced on dental films by a certain amount of exposure is determined. The variation in the density is determined not only by the amount but also by the quality of the rays. Films are reproduced that have been exposed to the same quantities of two qualities of roentgen rays and gamma radium rays. Pennies were placed on the corners of the same films to show the varying amounts of different qualities of rays absorbed by the penny.

They conclude that when properly done exposure to radiation can be measured quantitatively by either the ionization or the photographic methods. Probably neither is as accurate in the measurement of gamma radiation as in that of roentgen radiation but either is accurate enough to show whether further protective measures are necessary. The ionization chamber cannot be carried on the person so the photographic method is useful in determining the actual exposure of the individual. The ionization chamber is valuable for determining densities at different points in a room. The photographic method is a short cut and is reliable when calibrated with the effect of known amounts of radiation of the same quality; it also shows the cumulative effect of irradiation over a period of time.

In the discussion Dr. Quimby referred to the question of blood counts in determining whether irradiation was doing harm. Dr. Fricke had said that there are great variations in such counts. Dr. Quimby said that if the counts were always made under as nearly as possible the same circumstances they are of greater value. They make counts on their radium workers once a month—always at the same time of day and always by the same technician. If there is a downward trend for two or three months the worker is sent on a vacation. These workers have always come back after two weeks or a month with normal counts, so she does not think that a small change in the count is necessarily serious.

She also spoke of the change in quality of radiation with scatter and said that it was protection from scattered radiation that was being sought rather than from primary radiation. Therefore the change in quality is not so great as might be expected in going from 200 kv. roentgen radiation to gamma radium radiation. Her own measurements, and presumably Dr. Fricke's, were made on direct radiation; therefore any differences that may exist between different voltages were exaggerated and it is better to exaggerate in the matter of protection.

She was interested in the fact that Dr. Fricke found a ratio of 4 to 1 between the effects of gamma rays and roentgen rays on the film as that was what she had found some years ago. She has been saying that if a film is not so dark that print cannot be read through it it means an exposure of considerably less than 1 r of 200 kv. radiation. If the film is left for a week in the location being tested and is not darker than that protection is ample. If the gamma rays are one-fourth as effective the same amount can be tolerated in a month with gamma rays. This is a practical way of making a quick check-up.

Dr. Newell said he had a prejudice in favor of the film method of measurement because it makes it possible to measure the exposure you are getting in everyday life. He asked to have one of the slides placed on the screen on which gamma radiation seemed to have produced as much blackening as 200 kv. radiation. He suspected this was not due to the action of gamma rays but to that of corpuscular rays in the air which would not be dangerous to the bone marrow as they could not reach it.

Dr. Taylor said the last edition of X-ray Protection was Handbook 20 and the last edition of radium protection Handbook 23. These numbers should be used in writing for the handbooks as otherwise the older editions may be sent.

Dr. Fricke said the radium protection handbook had been published in *Radiology*, October, 1938. He said there were many possibilities of error in using pennies over the film because in such a method there is glancing radiation at different angles. He had used the method merely for contrast.—*Audrey G. Morgan.*

BERNSTEDT, RAGNAR. A determination of the dose constant, r/Imc-hour. *Acta radiol.*, 1940, *21*, 500–509.

A great many determinations have been made of the dose constant, r/Imc-hour, also called r/mgeh at 1 cm., but they vary a good deal. The differences are partly due to the differences of opinion in regard to the degree of correction of the values that are observed directly. The author describes and illustrates the apparatus and the method he used in determining the r/Imc-hour in two directions from a 50 mg. preparation, using a Sievert condenser chamber with a 4 mm. celluloid wall. In correcting for absorption in the wall of the preparation, account has been taken of the different shape of the wall in the two directions. The value of the constant found after all corrections have been made is 8.4 r/Imc-hour.—*Audrey G. Morgan.*

SANDSTRÖM, OLOF. Über Herddosierung mit konstanter Tiefenintensität bei Teleröntgentherapie. (Focal dosage with constant

deep intensity in teleroentgen therapy.) *Acta radiol.*, 1940, *21*, 443–456.

The author presents a new principle of dosage to be used in the method of ionization dosimetry now in use. By this method the irradiation is applied with a constant intensity at the depth of the lesion to be treated. This deep dose is obtained by two methods: first that of gradually varying the focal distance depending on the size of the field and the depth of the lesion and second a graduated change in the intensity of the tube current. For the determination of these different values for the focal distance, the author gives a mathematical formula on which are based the three dosage diagrams given. The curves represent the variation of the focal distance in proportion to the size of the field at the depth of the lesion as indicated by the parameters, so that a constant intensity is obtained at the depth of the lesion. The treatment time is obtained directly by dividing the deep dose desired by the constant depth intensity in r/minutes. Each of these dosage diagrams is followed by a diagram showing the surface dose and surface intensity in proportion to the deep dose and deep intensity. Directions are then given for using this dosage principle in teleroentgen therapy.—*Audrey G. Morgan.*

Luther, Wolfgang. Untersuchungen über den Verlauf der Strahlenreaktion im röntgenbestrahlten Mäusekarzinom. (Study of the course of the reaction in mouse carcinoma irradiated with roentgen rays.) *Strahlentherapie*, 1940, *68*, 669–687.

The author made a histological study of the reaction to roentgen irradiation of Ehrlich's carcinoma inoculated into mice. Two to three weeks after the inoculation with the tumor the animals were irradiated. They were given doses of 4,000 r and 11,000 r at a focus-skin distance of 27 cm., 90 kv., 4 ma., or a close irradiation at 4 cm. focus-skin distance, 50 kv., and 2 ma.

A unit of surface was chosen arbitrarily and the number of cells in it counted, also the number of mitoses in the same surface, the number of mitoses per thousand cells and the number of normal cells and the number injured by the so-called secondary effect. This means disturbances of the chromosomes. Complete sterilization, with permanent destruction of the capacity of the cells for division, was not observed in these tumors even with very large doses of 20,000 r, though it had been observed in some other material studied. The values obtained for these various points were plotted in the form of a reaction curve which is reproduced.

The reaction curve of these mouse carcinomata irradiated only once has the same form as the reaction curves of other objects (human carcinoma of the uterus) caused by the secondary effect, on fractional irradiation. Immediately after the irradiation there is a period practically free of mitoses; this is followed by a period of maximum increase of the mitoses, most of which are disturbed and this in turn by a period of minimum mitoses (period of breaking down of cells) and, if healing of the tumor is not brought about, a period of regeneration in which the number of uninjured mitoses rapidly increases. The different periods last only one to two days.

The mitoses injured by the secondary effect are not able to complete their division. They stop at a certain stage and the cells die. Regeneration of the tumor is brought about by a few exceptional cells which have apparently not been injured by the irradiation. The origin and physiology of these cells, which are also seen in normal tissue, is not known.

Complete destruction of all the cancer cells by the irradiation was not attained, even with 11,000 r. Cure of the cancer was brought about only when there were other factors that injured the cells besides the irradiation, such as ulceration, connective tissue reaction, etc.—*Audrey G. Morgan.*

Ducuing, J., Bugnard, L., Marques, P., and Cazabat, G. Etude expérimentale du rayonnement de roentgen diffusé; applications à roentgenthérapie. (Experimental study of scattered roentgen radiation; applications to roentgen therapy.) *J. de radiol. et d'électrol.*, March, 1939, *23*, 105–117.

One of the more important factors that determines penetrability of roentgen rays is the size of the portal. It is felt that this factor is too often neglected by radiotherapists. An ionization chamber placed at a certain depth measures a combination of both direct and scattered radiation. Increasing the size of the portal produces an increase in the dose measured in the depth. This is due to an increase in scattered radiation and indicates an increase in penetration. It is agreed that the biologic action in the tissues is governed solely by the quantity of energy absorbed.

Since measurements of scattered radiation depend greatly on the nature of the wall of the ionization chamber the results obtained are therefore only relative. A phantom made of rice, having a density of 0.88, was used. Being less than that of water it becomes difficult to apply the results directly to human tissue. In the experiments, practical homogeneity was obtained by using 200,000 volts and 1 mm. copper plus 1 mm. aluminum filtration.

The results are shown in charts and curves, and demonstrate some of the following points:

(1) Reducing the size of the portal reduces the coefficient of transmission and also changes the curve from an S with a large portal (25×25 cm.) to an exponential curve with the smaller (2×2 cm.).

(2) The larger the portal, the greater the penetration.

(3) Surface dose equals the incident dose plus retrograde radiation. The latter increases to a certain maximum as the size of the portal is increased. This also applies to the scattered radiation in the depths. For example, using a 25×25 cm. portal, the total radiation at 2 cm. depth equals 50 per cent direct and 50 per cent scattered radiation. At 5 cm. depth the ratio is one to two, and at 15 cm. the ratio is one to five.

Isodose charts were compiled to show that with large portals an improved dose homogeneity is obtained within the axis of the cone. However, at the periphery an underdosage occurs which is more marked when the portal is larger and the nearer the measurements are to the surface. The zone beyond the cone receiving appreciable radiation is larger with larger portals. It is interesting to note that, with supervoltages the isodose charts indicate a better homogeneity at the various depths. This is one of the few advantages of supervoltage radiation.

For the therapeutic application a pelvic tumor is given as an example; 200 kv. with 1 mm. copper and 1 mm. aluminum filtration at a target-skin distance of 80 cm. was used. The radiation was directed to a large anterior and a large posterior field, each approximately 800 cm. sq.; 250 r daily to a total of 5,000 r to each field was delivered. Occasionally a third field, vulvoperineal, measuring 150 cm. sq. was treated to a total of 1,500 r divided into three or four sessions. The experimental calculations indicated an excellent dose distribution throughout the pelvis with 3,800 r reaching the cervix.

The authors feel that this method is much more practical and efficient than the multiple field method.—*M. L. Sussman.*

TELLEZ PLASCENCIA, H. First measurements with the Spanish standard for the absolute determination of the international roentgen unit. *Radiology*, Jan., 1940, *34*, 82–94.

The author, who was delegate of Spain to the Fifth International Congress of Radiology and is Director of the Laboratory for Radiological Measurements in his country, describes in detail and illustrates the apparatus in use in that laboratory for such measurements. In 1932 they installed a Piccard compensation electrometer for determination of the charge of radium containers. In 1934 the standard chambers for the absolute measurement of the roentgen were adapted to this installation. They hope soon to compare this standard with the standard of other countries. They use a Stabilovolt S.R.V. roentgen-ray generator and two standard ionization chambers. Tables showing the results of their measurements are given and they believe that when it is possible to compare their standard with that of other nations only slight modifications of their method will be necessary.—*Audrey G. Morgan.*

KARG, C. Zur Radiumdosimetrie in der ärztlichen Praxis. (Radium dosimetry in medical practice.) *Strahlentherapie*, 1940, *68*, 530–533.

The determination of the roentgen by the ionometric method became established in roentgen dosimetry much sooner than in radium dosimetry, for in the latter it met with great technical and physical difficulties. But thanks to the work of Sievert these difficulties have been overcome. A measuring instrument called the condiometer is now available which the physician himself can use for dosimetric purposes in radium treatment.

The instrument is illustrated and the technical details of its use explained. The author compares the results of his own model experiment in measurement and the results reported by Weyrich in Vol. 68, p. 165 of *Strahlentherapie* in measuring the radium dosage in the treatment of a case of angioma. He calls attention to the necessity for careful measurement of dosage in the treatment of angiomas particularly, because they generally occur in young children and injury may result from overdosage on account of lack of homogeneity or from errors in measurement.—*Audrey G. Morgan.*

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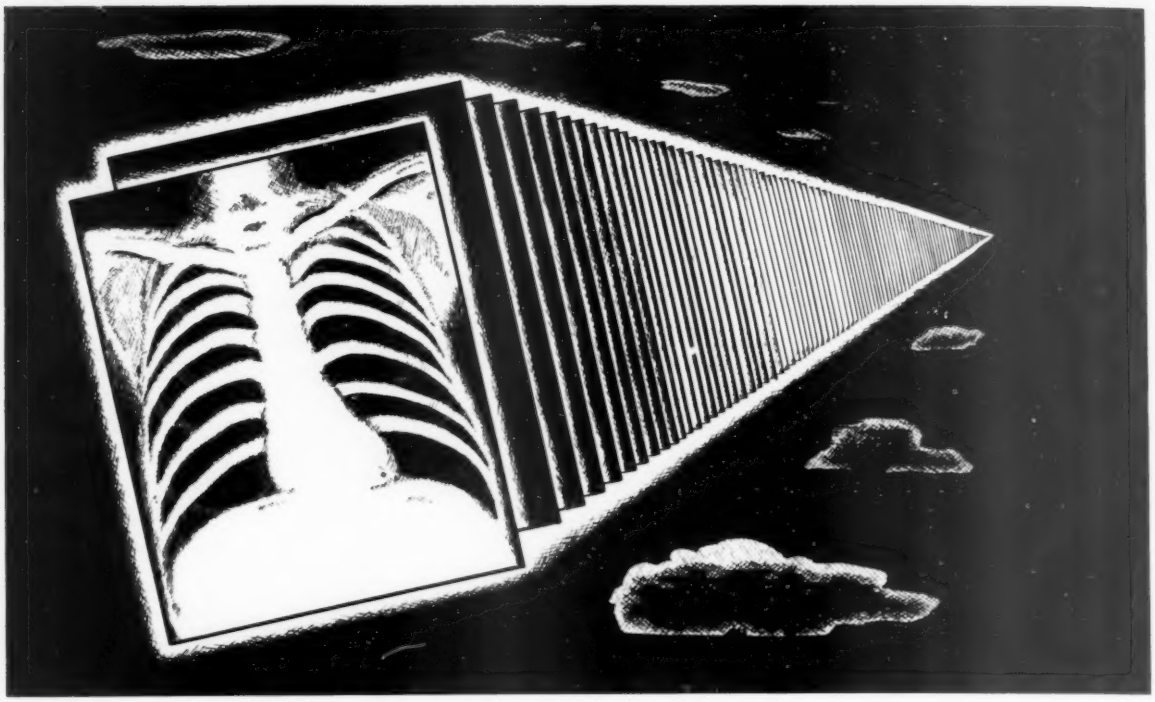

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